

## REVISIONAL NOTES ON AUSTRALASIAN SIMULIIDAE (DIPTERA).

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(With twenty Text-figures.)

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INTRODUCTION.

The time is not ripe for a full monographic treatment of the Australasian Simuliidae—too many life histories are still unknown; but we are stimulated to offer these notes, because we have had the opportunity to re-examine Tonnoir's extensive collection in the Division of Economic Entomology, C.S.I.R., and because Smart's (1945) revision has provided a basis on which the genera in the region may be reviewed. Moreover, our fauna presents anomalies which make Smart's definitions difficult to follow in some respects, so we feel that it would be helpful to discuss these problems now.

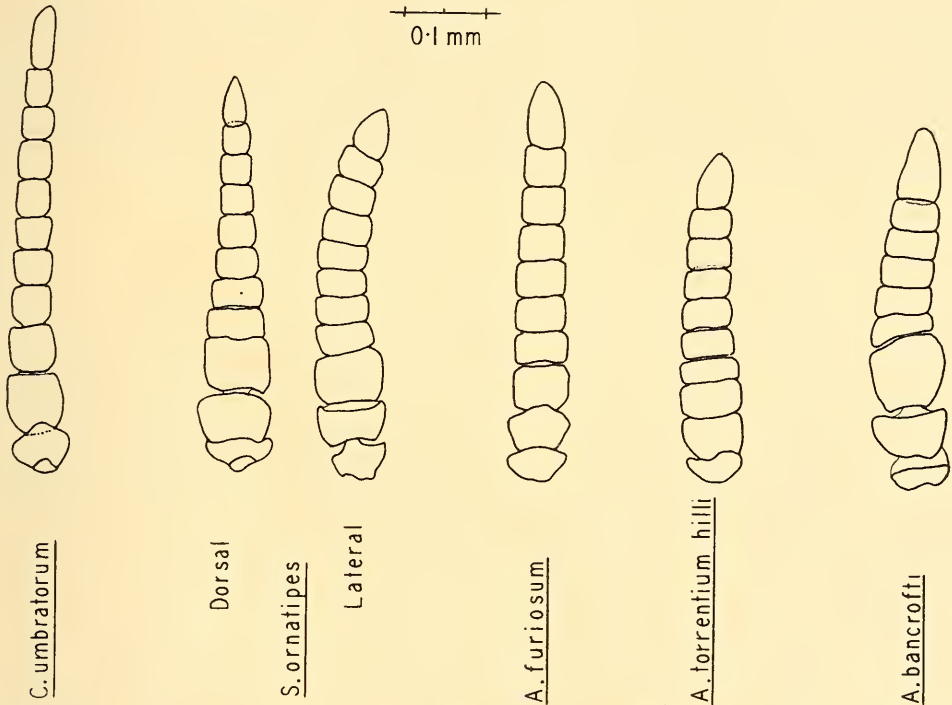
The Australasian fauna, as at present known, comprises 20 species and three subspecies from Australia and Tasmania, four species from New Guinea, and seven from New Zealand. The New Guinea species all belong to *Simulium*, as restricted by Edwards (1931, 1934) and Smart (1945), those from New Zealand are all *Austrosimulium*, and three genera are represented in Australia.

Tonnoir (1925) contributed most largely to our knowledge, later systematic papers being by Taylor (1927) on two species from Queensland, Drummond (1931) on the Western Australian species, Wharton (1948) on those from New Guinea, and the writers (1948) on those from Queensland. Enderlein (1922, 1936) had recorded three species from New Guinea. Edwards (1931, p. 131) transferred three of the Australian species of *Simulium* (*aurantiacum* Tonn., *terebrans* Tonn. and *unbratorum* Tonn.) to *Cnephia*, which was followed by Smart in his catalogue.

In the present paper, we propose to re-define the genera, record synonymy, give descriptive notes of the known species, and indicate the directions in which immediately profitable work might be undertaken. We consider that it does not help other workers at the present day to describe new species on adults only, and therefore only indicate certain forms by letters. It has, however, been necessary to refer to two of Tonnoir's MS. names, because the types were labelled and placed in the collection of the School of Public Health and Tropical Medicine, Sydney, before his death; both of these names are preoccupied.

As regards types, only the location of the holotype is mentioned, unless there is reason to refer to other types also.

This revision has been made possible, because Tonnoir's collection, including his undescribed material, was made available to us through the kindness of Dr. A. J. Nicholson, Chief of the Division of Economic Entomology, C.S.I.R., Canberra. We have also had access to Tonnoir's notes, and have been able to use them in places indicated in the text. In addition, we have received help with specimens and information from Messrs. T. G. Campbell, C.S.I.R., Canberra; K. J. Clinton, School of Public Health and Tropical Medicine, Sydney; R. H. Wharton, Department of Zoology, University of Sydney; A. R. Woodhill, Lecturer in Entomology, University of Sydney; and D. Mackerras, Sydney. To all of these, we express our thanks, especially to Mr. Wharton, for permission to use his undescribed material.



Text-fig. 1.—Antennae of females, showing range of variation.

Our thanks are due also to the Editor of the *Australian Journal of Scientific Research* for permission to incorporate elements from our earlier paper to complete some figures in the present work, and to the Editor of the *Bulletin of Entomological Research* for allowing us to use two figures of *A. cornutum* from Tonnoir (1925). As a result of their consideration, it should be possible for workers to identify all the known Australian "gill-spot" larvae and pupae from the illustrations given here.

We can only regret that our old friend, A. L. Tonnoir, did not survive to undertake this revision himself.

MORPHOLOGY.

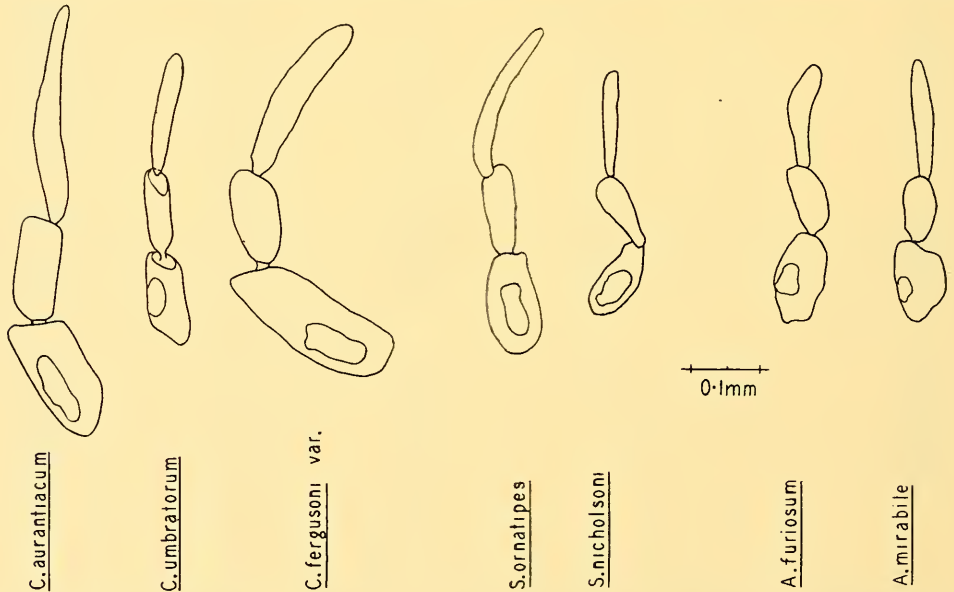
Apart from the extremely aberrant *Parasimulium* Mall., Edwards (1931) recognized seven subgenera of *Simulium*, five of which Smart (1945) restored to generic rank, namely: *Prosimulium* Roub. (Holarctic), *Cnephia* End. (Holarctic, Neotropical, Australian), *Gigantodax* End. (Neotropical), *Austrosimulium* Tonn. (Neotropical, Australian), and *Simulium* Latr. (cosmopolitan). The first three are obviously closely

related to one another, and seem to represent a line of evolution distinct from the rest of the family. *Austrosimulium* is also a compact group; its relationships are obscure, but appear to lie rather with the *Prosimulium* complex than with *Simulium*. *Simulium* itself is probably polyphyletic, though there are some features common to the species, which suggests that, as a whole, it represents a third main line of evolution in the family.

These three lines are, for the most part, well indicated in the structure of the pupae and cocoons, but the adults are less clearly separated, and the larvae scarcely at all. We have examined the Australian species to see whether they help or hinder solution of the problem of relationships, and present our notes below in order to avoid needless repetition in the generic definitions.

#### ADULTS.

*Head*: The antennae (Fig. 1) are eleven-segmented in *Cnephia* and *Simulium*, ten-segmented in *Austrosimulium* (except *A. bancrofti*, which has nine-segmented antennae). The number of segments is constant in every species we have examined. The terminal segment of the palp (Fig. 2) is long in some *Simulium* and the *aurantiacum* group of *Cnephia*, short in *Austrosimulium*, and short or intermediate in the *terebrans* group of *Cnephia*. There is considerable variability, and the taxonomic value of this character is limited. The upper eye-facets of the male are unusually enlarged in some species of the



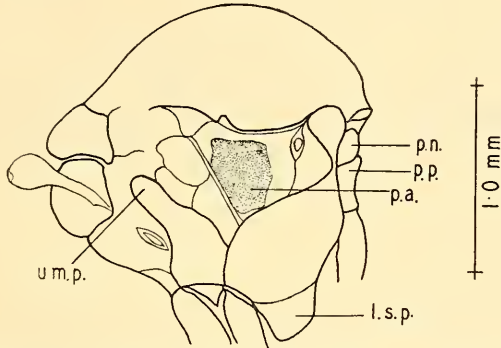
Text-fig. 2.—Distal three segments of palpi of females, showing range of variation.

*clathrinum* group of *Simulium*, but not in all, and this character has a limited value in suggesting relationships of obscure species (e.g., *S. oculatum* End.). We have not studied the bucco-pharyngeal armature.

*Thorax*: The scutum is strikingly humped in the *aurantiacum* group, normal in all other members of the family. The general pubescence is short, fine, and appressed in *Cnephia* and *Austrosimulium*, denser and with a stronger tendency for the hairs to develop into lanceolate scales in *Simulium*. As regards the pleural chaetotaxy, anterior pronotal and upper mesepimeral hairs are present in all species. Propleural hairs are present and conspicuous in all species of *Simulium*, usually absent in *Cnephia* (their presence in *C. aurantiacum* is a good specific character), and quite inconstant in *Austrosimulium*, even within some of the species. The possession of a conspicuous patch

of scales on the membranous area anterior to the wing-root and lower sternopleural\* hairs sharply distinguishes the *clathrinum* group of *Simulium* from all other Australasian members of the family. The areas referred to are shown in Figure 3.

*Wings*: Edwards (1931) indicated the importance of stouter spinules among the hairs on the costa, and a study of this character in the Australian material has given interesting results. *C. fergusonii* Tonn, apparently completely lacks spinules, and so its wing is separable from that of *Prosimulium* only by the unforked Rs. In *C. aurantiacum* spinules are present, but poorly differentiated. They are better developed in the remaining species of *Cnephia* and in *Austrosimulium*, but are especially conspicuous and thorn-like in *Simulium*. Of greater local importance is the presence of similar spinules among the hairs on the upper surface of  $R_1$  in all the species of *Simulium*, and their absence in both the other genera.



Text-fig. 3.—Lateral view of thorax of female *C. aurantiacum*. p.n. Anterior pronotal lobes. p.p. Propleuron. p.a. Membranous prealar area. l.s.p. Lower sternopleural area. u.m.p. Upper mesepimeral area. (Hairs omitted.)

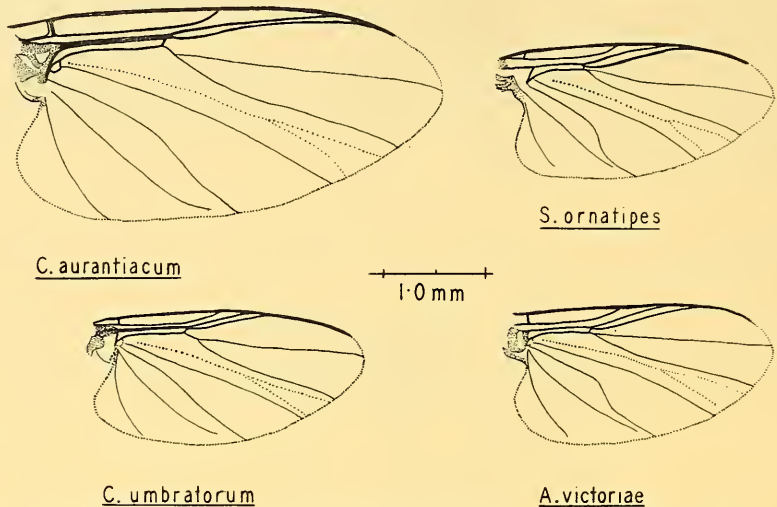
Sc is haired below in all species; R (usually referred to as basal section of radius) haired above in all, except one aberrant member of the *clathrinum* group;  $R_1$  haired above in all;  $R_2$  haired below throughout its length, and above on its distal section, in all species. In *Cnephia* and *Austrosimulium* the hairs on the upper surface of  $R_2$  commence about opposite the tip of  $R_1$ ; in *Simulium* they are practically restricted to the distal end, where  $R_2$  comes into apposition with costa. *A. mirabile* is aberrant in having the hairs on the veins largely concentrated in tufts.

The small cell at the base of the wing (Edwards, 1931) is sometimes difficult to see, but is indicated in all species of *Cnephia* and *Austrosimulium*, absent in *Simulium*.  $Cu_1$  is gently sinuous in the *aurantiacum* group of *Cnephia*, almost straight in *C. umbratorum*, and with a strong double curve in all other members of the family (Fig. 4). This last character, though a relative one, seems to be a useful taxonomic feature of the wing.

*Legs*: We have not been impressed with the chaetotaxy of the legs or the form of tibiae and metatarsi as assisting in generic or group recognition, though the very long hairs described by Enderlein on the fore tarsi seem to be rather characteristic of the *clathrinum* group. A calcipala is present in all species except in the eastern form of *C. fergusonii*, though it is indicated in the Western Australian race. It is particularly large and conspicuous in *C. aurantiacum* and its allies. Similarly, the pedisulcus is well defined in *Simulium* and *Austrosimulium*, present but shallow in most *Cnephia*, and absent only in the two races of *C. fergusonii*. Teeth on the female claws may be present or absent in all three genera, and so (as both Edwards and Smart have pointed out) have little taxonomic value for major groupings. Most males have the peculiar untoothed claws figured by Tonnoir, but a few (e.g., *A. crassipes*, *A. victoriae*) have a minute basal tooth.

\* This is the area called mesosternal by Edwards (1934); but it corresponds with the lower sternopleural area of other groups, and is clearly divided by a median, ventral suture, which is curious for a sternal plate.

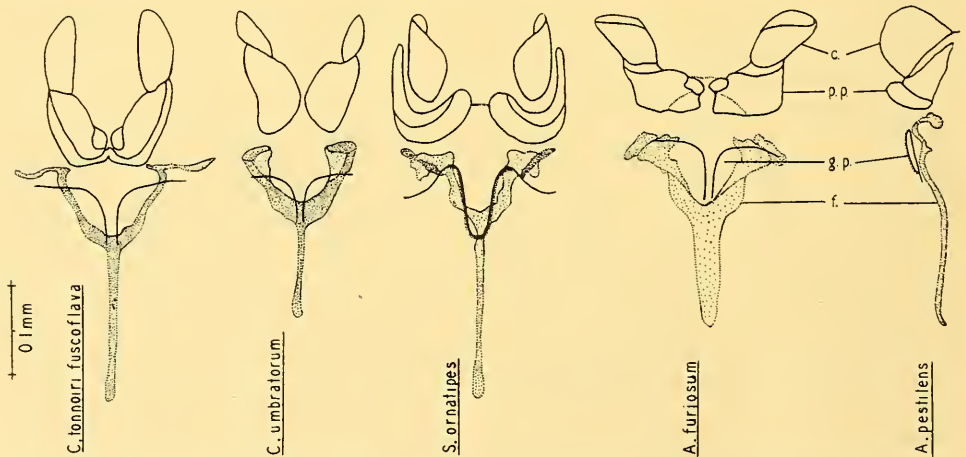
*Abdomen:* The abdomen is strongly hirsute in the *aurantiacum* group, densely covered (at least over the greater part of the dorsum) with scales in *Simulium*, and relatively bare in *Austrosimulium* and the *terebrans* group of *Cnephia*. These features, in combination with the general pubescence of the thorax and legs, give the several



Text-fig. 4.—Wings of females, showing variation of  $Cu_1$  and small cell.

groups quite distinctive appearances, so that an insect can be placed with considerable accuracy by means of a hand-lens alone.

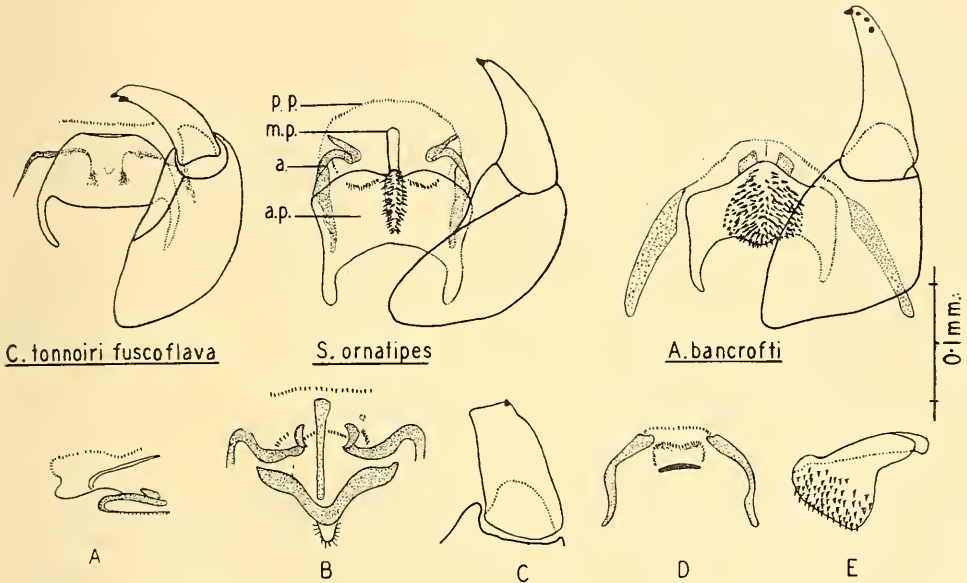
*Female genitalia:* An examination of these structures was disappointing. There were differences between species (which could be recognized as easily by more accessible characters) but few between groups. The anterior gonopophyses are mostly delicate,



Text-fig. 5.—Genitalia of females. c. Cerci. p.p. Paraprocts. g.p. Anterior gonopophyses. f. Genital fork. (Terminology after Gibbins, 1934.)

but are strongly chitinized in *S. ornatipes* (giving the appearance of a "cleft sternite"), and to a lesser degree in some of the darker species of *Austrosimulium*. The paraprocts (basal segment of cercus of Mackerras and Fuller, 1942), generally triangular or quadrate, are elongate in the *aurantiacum* group, and fused basally in the midline in

*C. tonnoiri fuscoflava*. The cerci are more or less semilunar lobes in lateral view in nearly all the species, and the tenth segment is small and lightly chitinized in nearly all. The genital fork alone showed useful differences, its stem being relatively long and slender in dorso-ventral view in *Simulium*, shorter and broader in *Austrosimulium*. The *aurantiacum* group of *Cnephia* corresponded to *Simulium*, but the *terebrans* group tended to be intermediate, in that the stem was relatively short though slender. *C. aurantiacum* is the only species we have seen with a strongly sculptured spermatheca.



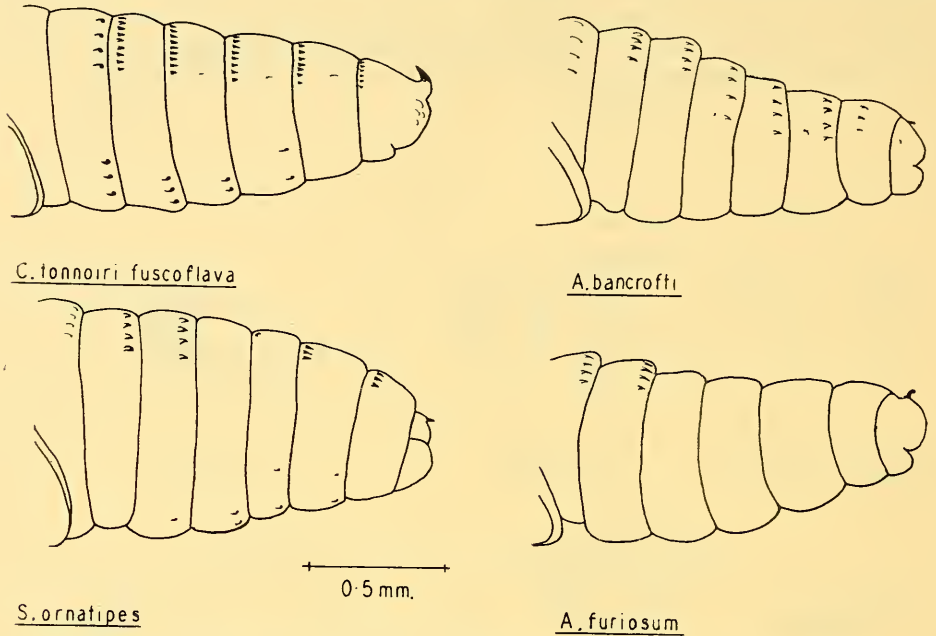
Text-fig. 6.—Genitalia of males. p.p. Posterior part of phallosome. m.p. Median piece. a. Apodeme. a.p. Anterior part of phallosome. Lower row: A. Sagittal sectional view of phallosome of *C. tonnoiri fuscoflava*. B. End view of phallosome of *S. ornatipes*. C. Internal view of style of *S. ornatipes*. D. Dorsal view of posterior part of phallosome and apodemes of *S. clathrinum*. E. Lateral view of anterior part of phallosome of *A. bancrofti*. (Terminology after Gibbins, 1935.)

*Male genitalia*: These also were not as useful as might have been expected. Nevertheless the number of spines on the style differ in the genera (Fig. 6), and the ventral surface of the anterior part of the phallosome (Gibbins, 1935) is swollen and coarsely setulose in *Austrosimulium*, whereas it is more nearly flat and smooth in the other genera. The most distinctive and complex hypopygium is possessed by *S. ornatipes*, which has, not only a median, setulose, ventral keel on the anterior part of the phallosome, but powerful apodemes, and well developed structures on the posterior part. This is the only species with a clearly defined, heavily chitinized median process, though the presence of one is indicated also in a few species of *Austrosimulium*. The style is longer than the coxite in only one species (*A. bancrofti* Tayl.). When we come to *A. furiosum* and its relatives, the males of which cannot be separated satisfactorily on external characters, we find that, while there do appear to be differences in the number and arrangement of the denticles on the posterior part of the phallosome, these parts are so difficult to see, and errors due to position and distortion are so likely that they have little practical value.

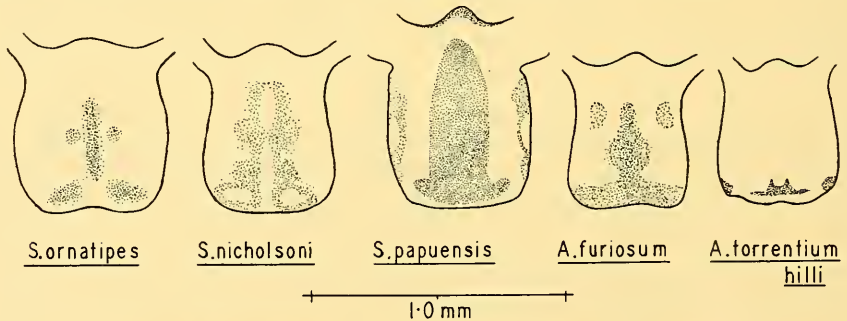
PUPAE.

The pupae offer, not only the best specific characters, as Tonnoir (1925) pointed out, but the best generic characters, too, the most useful being found in the form of the thoracic respiratory organs and the abdominal armature of strong spines and hooks

(Fig. 7). These features are described below in the definitions of the genera, but it may be remarked here that we would have been doubtful of the wisdom of recognizing *Cnephia* as a distinct genus in the Australian fauna, if it were not for the relationship



Text-fig. 7.—Representative pupae. Lateral view of abdomen, showing armature. shown by the known pupae and cocoons to *Prosimulium* and its allies. *Simulium papuense* Wh. is unusual, in that the respiratory organs are of arborescent *Prosimulium* form, whereas the abdominal chaetotaxy is typical of *Simulium*.



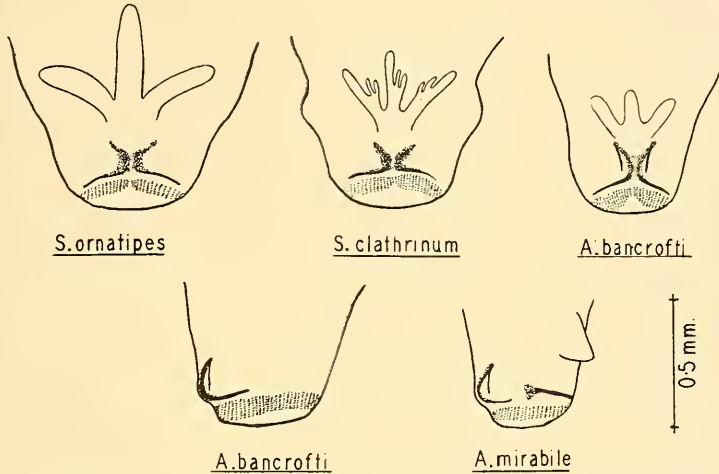
Text-fig. 8.—Heads of larvae, showing variation in pattern. (For *papuensis* read *papuense*.)

LARVAE.

The larvae are rather uniform, and we have only found two characters which correlate with groupings based on pupae and adults. The backwardly directed strut in the anal armature (Fig. 9) occurs only (and constantly) in *Austrosimulium*, and the form of the pupal gill-spot varies in the three genera (Fig. 19).

It is apparent that *Austrosimulium* is well differentiated in all stages, even the cocoons being recognizable generically by their failure to enclose the abdomen of the pupa ventrally. The cocoons also distinguish *Cnephia*, perhaps better than any other

feature, but the abdominal chaetotaxy of the pupa, too, is distinctive. Other characters separating *Cnephia* from *Simulium*, unfortunately, are relative, or show exceptions, like the pupal gills of *S. papuense* or the propleural hairs of adult *C. aurantiacum*, so that their usefulness is correspondingly impaired. Nevertheless, when they are treated collectively, and when obvious inter-specific relationships are taken into account, too, the groups do appear natural, and give the impression that they can be accepted with reasonable confidence.



Text-fig. 9.—Terminal segments of larvae; top row: dorsal view, showing anal sclerite and rectal gills; bottom row: lateral view, showing ventral papillae and chitinous ring in *A. mirabile* and their absence in *A. bancrofti*.

#### DISTRIBUTION.

The species of *Cnephia* are typically "Antarctic" in distribution, occurring in Tasmania and the south-eastern highlands of the mainland, with extensions to south-western Australia and to Stradbroke Is. in Queensland. Their relationships, too, obviously lie with the *Prosimulium* complex, which radiated widely in the Andean sub-region of South America, where it is represented by the genera *Cnephia* and *Gigantodax*.

*Austrosimulium* is also a southern genus, well represented in Tasmania, but extending more widely on the mainland than *Cnephia*, and showing a capacity to thrive in semi-arid, inland country. Its affinities are obscure, but its "Antarctic" origin is clear from the occurrence of species in New Zealand and South America.

On the other hand, *Simulium ornatipes* is a typical *Eusimulium* with Austro-Malayan affinities, and the members of the *clathrinum* group belong to the same zoogeographical element, being distributed in the northern half of the continent and New Guinea, and finding their nearest relationships with Edwards' (1934) Group C from Java and Sumatra. It is of considerable interest that such a small and specialized group as the Simuliidae should present in miniature so much of the zoogeographical picture of the Australian fauna as a whole.

As regards species, it has become clear that many are much more widely distributed than Tonnoir imagined (Table 1). *S. ornatipes* is the outstanding example, for it extends from Perth right through the eastern States and into New Guinea. Even some of the obscure species of *Austrosimulium*, like *A. furiosum*, are now known to range from Western Australia to southern Queensland. With these extended ranges, there naturally arises the question of subspeciation. Tonnoir (MS.) had noted its occurrence in *C. fergusonii*, and we believe that we have seen it in *C. tonnoiri* and *A. torren-tium*, but it has not been widely searched for, and an interesting field here awaits the investigator.



TABLE 1.

Species.	Q.	N.S.W.*	Vic.	Tas.	S.A.	W.A.	Other.
<i>Cnephia</i> —							
<i>aurantiacum</i> (Tonn.) ..		x	x	x			
<i>tonnoiri tonnoiri</i> (Drum.) ..		x				x	
<i>tonnoiri fuscoflava</i> M. and M.	x						
<i>umbratorum</i> (Tonn.) ..			x				
<i>terebrans</i> (Tonn.) ..		x	x				
sp. <i>A</i> (nr. <i>terebrans</i> ) ..						x	
<i>fergusoni</i> (Tonn.) ..		x			x		
<i>fergusoni</i> var. ..						x	
<i>Simulium</i> —							
<i>ornatipes</i> Sk. ..	x	x			x	x	N.G.
<i>clathrinum</i> M. and M. ..	x						
<i>papuense</i> Wh. ..							N.G.
<i>oculatum</i> (End.) ..							N.G.
<i>wilhelmlandae</i> Smart ..							N.G.
<i>nicholsoni</i> M. and M. ..	x						
<i>faheyi</i> Tayl. ..	x						N.T.
sp. <i>B</i> (nr. <i>faheyi</i> ) ..							N.T.
<i>Austrosimulium</i> —							
<i>mirabile</i> M. and M. ..	x						
<i>crassipes</i> Tonn. ..		x	x				
<i>cornutum</i> Tonn. ..		x	x	x			
sp. <i>C</i> (nr. <i>cornutum</i> ) ..						x	
<i>bancrofti</i> (Tayl.) ..	x	x		x		x	
<i>pestilens</i> M. and M. ..	x						
<i>furiosum</i> (Sk.) ..	x	x	x	x	x	x	
<i>victoriae</i> (Roub.) ..	x	x	x	x			
<i>torrentium torrentium</i> Tonn.				x			
<i>torrentium hilli</i> n.subsp. ..		x					
<i>vezans</i> (Mlk.) ..							N.Z.
<i>ungulatum</i> Tonn. ..							N.Z.
<i>australense</i> (Schin.) ..							N.Z.
<i>tillyardi</i> Tonn. ..							N.Z.
<i>laticorne</i> Tonn. ..							N.Z.
<i>multicorne</i> Tonn. ..							N.Z.
<i>longicorne</i> Tonn. ..							N.Z.

\* Including Australian Capital Territory.

## KEYS TO SPECIES.

These keys are purely for preliminary identification, and subspecies are not included. As in an earlier paper, it is considered better to rely on figures rather than keys for the identification of cocoons (Figs. 11, 20), pupae (Figs. 12, 18, 20), and larvae old enough to show a gill spot (Figs. 13D, 19).

As we have nothing to add to Tonnoir's keys (1925, pp. 230–232), the New Zealand species of *Austrosimulium* are omitted.

*Females.*

1. Antennae eleven-segmented ..... 2  
Antennae ten- (or nine-) segmented ..... 14
2.  $Cu_1$  with a gentle curve; orange to brown sps.; usually large ..... 3  
 $Cu_1$  with a strong double bend; dark sps.; medium-sized to small ..... 5
3. Medium-sized brown sp., with  $Cu_1$  almost straight, and abdomen sparsely pubescent above ..... *C. umbratorum* (Tonn.)  
Large orange sps. with  $Cu_1$  distinctly curved, and abdomen strongly hirsute above ..... 4
4. Propleural hairs present; wing without definite spot at fork of R .. *C. aurantiacum* (Tonn.)  
No propleural hairs; wing with dark spot at fork of R ..... *C. tonnoiri* (Drum.)
5. Abdomen with sparse, short pubescence, the general appearance of the dorsum being bare or lightly tomentose ..... 6  
Abdomen with a dense, more or less complete, covering of strong hairs and lanceolate scales ..... 8

6. Calcipala absent or minute; propleural hairs well developed .....	<i>C. fergusoni</i> (Tonn.)	
Calcipala well developed; propleural hairs few or absent .....		7
7. Small, brownish black sp.; halter with knob dark brown; lateral and apical abdominal hairs yellow .....	<i>C. terebrans</i> (Tonn.)	
Larger, greyish black sp.; halter with knob reddish brown; lateral and apical abdominal hairs black .....	<i>Cnephia</i> sp. A.	
8. Prealar area bare (legs conspicuously marked with black and yellow, fore and mid coxae yellow) .....	<i>S. ornatipes</i> Sk.	
Prealar area with a patch of pale scales (leg pattern not as above) .....		9
9. Scutum black, with three irregular, longitudinal golden lines; claws with strong basal tooth .....	<i>S. clathrinum</i> M. & M.	
Scutum with pale scales more diffusely arranged; claws with at most a minute basal tooth .....		10
10. Minute, pale sp.; antennae entirely yellowish fawn; femora and tibiae predominantly creamy yellow .....	<i>Simulium</i> sp. B.	
Small to medium spp.; antennae with only basal segments pale; femora and tibiae predominantly dark .....		11
11. Abdomen with last three tergites black and rather smooth .....	<i>S. oculatum</i> (End.)*	
Abdomen with at least a scattering of pale lanceolate scales on last three visible tergites .....		12
12. Medium sized, stouter sp.; hind metatarsus as long as tibia .....	<i>S. papuense</i> Wh.	
Smaller, more slender sps.; hind metatarsus shorter than tibia .....		13
13. Black and silvery sp.; pleurae dark grey, not contrasting with area adjacent to shoulders .....	<i>S. nicholsoni</i> M. & M.	
More brown or grey and golden sp.; pleurae pale grey, contrasting strongly with brown markings on and adjacent to shoulders .....	<i>S. faheyi</i> Tayl.	
14. Antennae with an orange band covering fourth to sixth segments; wing with three dark spots .....	<i>A. mirabile</i> M. & M.	
Antennae with at most the basal segments pale; wing without spots .....		15
15. Dorsum of abdomen with ashy tomentose markings .....		16
Abdomen entirely dark dorsally .....		17
16. Antennae nine-segmented .....	<i>A. bauerofti</i> (Tayl.)	
Antennae ten-segmented .....	<i>A. pestilens</i> M. & M.	
17. Claws with strong basal tooth .....		18
Claws without tooth .....		20
18. Small, greyish sp.; abdomen with tergites covered with velvety black tomentum .....	<i>Austrosimulium</i> sp. C	
Blackish sps.; abdomen entirely dull brownish black .....		19
19. Larger sp.; hind metatarsus normal; calcipala nearly as wide as metatarsus, not separated by a notch .....	<i>A. cornutum</i> Tonn.	
Smaller sp.; hind metatarsus incrassate; calcipala relatively narrower, separated by a notch .....	<i>A. crassipes</i> Tonn.	
20. Abdomen with tergites covered with velvety black tomentum .....	<i>A. furiosum</i> (Sk.)	
Abdomen entirely dull brown, not tomentose .....		21
21. Larger, blackish sp. antennae long (Fig. 17A) .....	<i>A. victoriae</i> (Roub.)	
Smaller, greyish sp.; antennae short (Fig. 17B) .....	<i>A. torrentium</i> Tonn.	
The female of <i>S. wilhelmlandae</i> Smart (New Guinea) is not known.		

Males.

1. Antennae eleven-segmented .....		2
Antennae ten (or nine-) segmented .....		8
2. Large, orange sps. ....		3
Medium to small, dark sps. ....		4
3. Wing without spot at bifurcation of R .....	<i>C. aurantiacum</i> (Tonn.)	
Wings with dark spot at bifurcation of R .....	<i>C. tonnoiri</i> (Drum.)	
4. Prealar area bare; legs conspicuously marked with black and yellow ....	<i>S. ornatipes</i> Sk.	
Prealar scales present; legs not so marked .....		5
5. Antennae yellow-brown; first two segments of abdomen yellow ochre .....	<i>S. wilhelmlandae</i> Smart*	
Antennae and basal segments of abdomen dark .....		6
6. Upper facets of eye normally enlarged; small sp. ....	<i>S. nicholsoni</i> M. & M.	
Upper facets of eye greatly enlarged; larger spp. ....		7
7. Scutum with three irregular golden lines .....	<i>S. clathrinum</i> M. & M.	
Scutum with golden hairs diffuse .....	<i>S. papuense</i> Wh., <i>S. oculatum</i> (End.)*	
8. Antennae with orange band covering segments 4-6; wing with three black spots in radial field .....	<i>A. mirabile</i> M. & M.	
Antennae dark (except sometimes at base); wings clear .....		9

\* Placed here by presumption from other group characters.

9. Abdomen with shiny, lateral, ashy patches on fifth and sixth segments ..... 10  
 Abdomen entirely black ..... 11
10. Antennae nine-segmented ..... *A. bancrofti* (Tayl.)  
 Antennae ten-segmented ..... *A. pestilens* M. & M.
11. Hind metatarsus incrassate; calcipala small ..... *A. crassipes* Tonn.  
 Hind metatarsus normal; calcipala at least half width of shaft ..... 12
12. Calcipala nearly as wide as metatarsus ..... *A. cornutum* Tonn.  
 Calcipala at most two-thirds as wide as metatarsus .....  
 ..... *A. furiosum* (Sk.), *A. victoriae* (Roub.), *A. torrentium* Tonn.

#### Larvae.

1. Anal sclerite without a backwardly-directed strut ..... 2  
 Anal sclerite with a backwardly-directed strut on lateral side of anterior arm ..... 7
2. Rectal gills compound ..... 3  
 Rectal gills simple ..... 4
3. Head pattern irregular; ventral papillae absent ..... *S. clathrinum* M. & M.  
 Head pattern conspicuous, bullet-shaped; ventral papillae present ..... *S. papuense* Wh.
4. Ventral papillae absent ..... 5  
 Ventral papillae present ..... 6
5. Circlelet with about 30 minute teeth per row ..... *C. aurantiacum* (Tonn.)  
 Circlelet with 15-25 larger teeth per row ..... *C. tonnoiri* (Drum.)
6. Head pattern positive\* type; robust, dark species ..... *S. ornatipes* Sk.  
 Head pattern negative\* type; more delicate, yellowish species ..... *S. nicholsoni* M. & M.
7. Ventral papillae absent ..... 8  
 Ventral papillae present ..... 9
8. Anal sclerite stout, angle between anterior limbs usually less than 90°; submental teeth seven ..... *A. bancrofti* (Tayl.)  
 Anal sclerite delicate, angle between anterior limbs usually greater than 90°; submental teeth eleven ..... *A. pestilens* M. & M.
9. A chitinous rod encircling tip of abdomen ventral to anal sclerite ..... 10  
 No such rod present ..... 12
10. Submental plate with central tooth not projecting beyond adjacent teeth; basal segment of antenna more than half length of distal segment ..... *A. cornutum* Tonn.  
 Submental plate with central tooth projecting conspicuously beyond adjacent teeth; basal segment of antenna less than half length of distal segment ..... 11
11. Ends of chitinous ring swollen (Fig. 9) ..... *A. mirabile* M. & M.  
 Ends of chitinous ring not swollen ..... *A. crassipes* Tonn.
12. Antennae dark brown or blackish ..... *A. victoriae* (Roub.)  
 Antennae pale ..... 13
13. Basal segment of antenna equal in length to distal segment ..... *A. furiosum* (Sk.)  
 Basal segment of antenna markedly longer than distal segment ..... *A. torrentium* Tonn.

#### The Genus CNEPHIA Enderlein.

*Adults:* Antennae eleven-segmented; wings with spiniform macrotrichia more or less developed on costa, but none on R<sub>1</sub>; small cell present; pedisulcus shallow or absent. Genotype: *Simulium pecuarum* Riley, Nearctic (Sharp, 1945).

This definition is necessarily brief, details being best reserved for the groups; but we may, for the purpose of clarifying the relationships of Australian species, accept the genus *Cnephia* for those listed here, with the feeling that further study may reduce rather than increase the number of genera recognized in the *Prosimulium* complex.

#### The *aurantiacum* group.

*Adults:* Orange species, with strongly humped thorax; pubescence short, fine; palpi with terminal segment as long as the previous two together; propleural hairs present or absent; wing with Cu<sub>1</sub> gently sinuous; hind legs with large, conspicuous calcipala, pedisulcus shallow but distinct; claws of female with strong basal tooth; abdomen of female strongly hirsute; genital fork of *Simulium* type; male hypopygium with two spines on the style; anterior part of phallosome (Fig. 6A) with flat, very delicately setulose membrane ventrally, a strongly chitinized distal edge, and a chitinized dorsal surface; posterior part with a pair of hooks near the mid line, and patches of irregular denticles medial to distal end of apodeme; no median process detected.

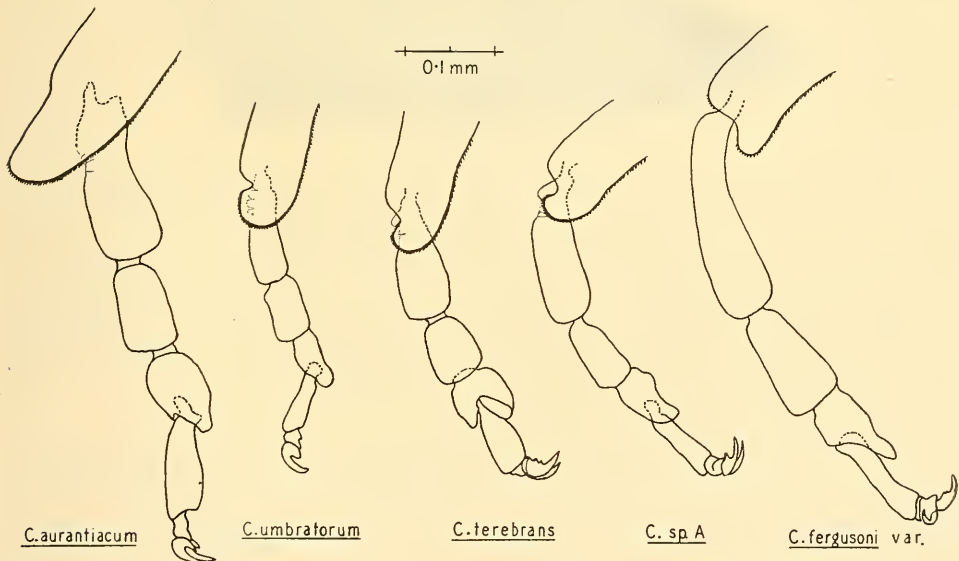
\* Edwards (1934) defines the markings of the head-capsule as "positive" when the insertions of the muscles are darker than the surrounding chitin, "negative" when they are paler.

*Pupa*: With much branched respiratory apparatus (Fig. 11). Abdomen with a row of flat, triangular, backwardly directed, *sub-basal* spines on dorsal surface of segments 5-9; *sub-apical* dorsal and ventral hooks also present on some segments; terminal spines very large and forwardly directed (Fig. 7).

*Cocoon*: Coarsely woven, of indefinite shape, often incorporating foreign material (Fig. 11).

*Larva*: Not separable from *Simulium*, except for the pupal gill spot, the filaments of which curve first backwards and then downwards and forwards, returning upon themselves (Fig. 19, top row); anal gills simple; no ventral papillae; anterior limbs of anal sclerite without backwardly directed strut.

Smart's (1945) definition of *Cnephia* is too restrictive to fit this group, for example in describing the calcipala as "minute or absent", and he appears to be in error in saying that the pupa lacks terminal spines. On the other hand, our species show an almost perfect transition from *Cnephia* to *Gigantodax* as recognized by Edwards (1931),\* and it is to be noted that the abdominal armature of the pupa is of the *Gigantodax* and not the *Cnephia* type (compare our Fig. 7 with Edwards' Fig. 12 *e* and *f*). However, *Gigantodax* has no small cell in the wing, and the respiratory organs of the pupa are rather different. *Prosimulium* itself is only to be separated by the absence of spines on costa and the forked Rs, and in both respects Australian material shows annectant forms (see Edwards', 1931, remarks on an incipient fork in Rs of *C. aurantiacum*).



Text-fig. 10.—Hind tarsi of *Cnephia* spp., females.

#### CNEPHIA AURANTIACUM (Tonnoir).

*Simulium aurantiacum* Tonnoir, 1925, p. 234. Type in Division of Economic Entomology, C.S.I.R., Canberra.

*Cnephia aurantiacum* (Tonnoir), Edwards, 1931, p. 131; Smart, 1945, p. 498.

*Adults*: Large orange species, with yellow legs and antennae, and dark, hirsute abdomen. A group of strong, yellow propleural hairs present. Wing without dark spots at root and at fork of R, but lightly infuscated towards tip. Calcipala very large, as wide as metatarsus (Fig. 10); pedisulcus shallow but distinct. Spermatheca coarsely rugose or tuberculate.

\* He incidentally shows the gently sinuous  $Cu_1$  of *Cnephia* clearly in his Fig. 8a.

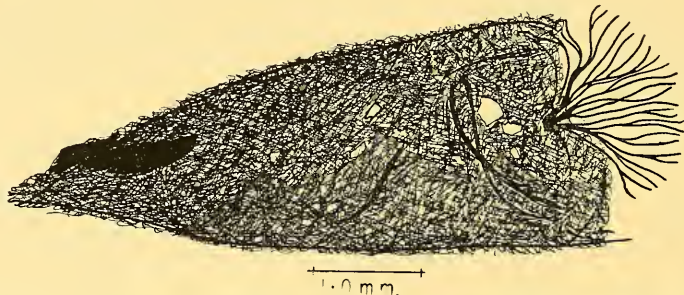
*Cocoon*: Coarsely woven and bag-like, but with some tendency to a simple "slipper" form; incorporates much foreign material.

*Pupa*: Gill-filaments relatively fine, about 40 in number.

*Larva*: Posterior cirlet with about 30 small teeth per row; gill-spot wide (Fig. 19).

*Distribution*.—Tasmania: National Park (Russell Falls), Dec.; Cradle Valley, Jan.-Feb.; St. Patrick R.; Burnie; Brunie Is.; Mt. Farrell. Victoria: Sassafras, Oct.; Mt. Dandenong (Sherbrook Falls), Oct. A.C.T.: Blundell's, Oct. New South Wales: Mt. Kosciusko (Digger's Ck.), A. J. Nicholson; Jenolan Caves, J. C. Wiburd; Brown Mt., Feb.; Fitzroy Falls, Nov.; Wentworth Falls, Nov.; Mt. Wilson, Nov. (*type locality*). All not otherwise indicated are coll. A. L. Tonnoir.

*Biology*: Associated with fast-running, clear mountain streams; cocoons often in moss or obscured by filamentous algae. Adults taken by sweeping vegetation along creek banks; not known to feed on blood. Tonnoir's (MS.) notes are: "This is not a common species, as it seems restricted in its habitat, which is in mountain streams—rather shady—in places where current very swift in or above waterfalls, yet where stones not bare but somewhat covered with vegetation. Also, where it occurs, it is not very abundant; the larvae are rather isolated, but pupae are found in clusters, often in moss, very rarely on stones."



Text-fig. 11.—Cocoon of *C. tonnoiri tonnoiri*, showing included foreign material.

#### CNEPHIA TONNOIRI TONNOIRI (Drummond).

*Simulium tonnoiri* Drummond, 1931, p. 6; Smart, 1945, p. 515. Type in Division of Economic Entomology, C.S.I.R., Canberra.

*Adult*: Orange, with dark, hirsute abdomen; hind legs darker than in *C. aurantiacum*. No propleural hairs. Wing with a conspicuous dark mark on transverse group of veins near root, and another covering the fork of R and extending on to r-m; wing-tip clear. Calcupala and pedisulcus as in *C. aurantiacum*. Spermatheca almost smooth.

*Cocoon* (Fig. 11): Similar to *C. aurantiacum*.

*Pupa*: With 20 to 30 moderately stout gill filaments.

*Larva*: Posterior cirlet with 18–24 medium-sized teeth per row; gill spot (Fig. 19) distinctly narrower than in relatives.

*Distribution*.—Western Australia: Lesmurdie, Oct., F. H. N. Drummond (*type locality*); Perth, July, Drummond; Wongong Brook, Aug., Nicholson. A.C.T.: Canberra, Nov., Tonnoir; Coree Ck., Nov., Jan., Tonnoir.

*Biology*: Described by Drummond as breeding in a wide range of stream types. Habits of adults unknown.

#### CNEPHIA TONNOIRI FUSCOFLAVA M. and M.

*Cnephia tonnoiri fuscoflava* Mackerras and Mackerras, 1948, p. 236. Type in Division of Economic Entomology, C.S.I.R., Canberra.

*Adult*: Darker than typical subspecies; mid and hind legs suffused with black; dark rim of anterior thoracic spiracle conspicuous.

*Cocoon*: As in typical subspecies.

*Pupa*: With 15–20 gill filaments which are distinctly coarser than in typical form.

*Larva*: Posterior cirlet with about 15 relatively large teeth per row.

*Distribution*.—Queensland: Stradbroke Is., Dunwich (*type locality*), Sept. (E. N. Marks), Oct. (authors); Little Nerang R., Aug. (authors).

*Biology*: Early stages in small, moderately fast, clear but peaty channels in coastal strip; cocoons much obscured by filamentous algae. Habits of adults unknown.

*Note*.—The above three forms are closely related, and intergrade in many characters, but *C. aurantiacum* stands out by possessing propleural hairs and lacking dark spots on the wings.

#### The *terebrans* group.

*Females*: Dark, unadorned species, resembling *Austrosimulium*; thorax normal; pubescence short, fine; palpi of *Austrosimulium* type; propleural hairs present or absent;  $Cu_1$  with a strong double curve as in *Simulium* and *Austrosimulium* (except *C. umbratorum*); calcipala present or absent; pedisulcus inconspicuous or absent; claws with large or small tooth (sometimes double) or none; abdomen with sparse, fine pubescence, giving a bare appearance as in *Austrosimulium*; genital fork of *Simulium* type, but stem relatively short.

The essential feature of this group is the combination of eleven-segmented antennae with an *Austrosimulium* abdomen. As only females are known, its affinities cannot be discussed profitably, but it clearly cannot be placed in *Simulium* (*s. str.*), and *C. umbratorum* seems to provide a link with the *aurantiacum* group. The early stages should be full of interest.

#### CNEPHIA UMBRATORUM (Tonnoir).

*Simulium umbratorum* Tonnoir, 1925, p. 237. Type in Division of Economic Entomology, C.S.I.R., Canberra.

*Cnephia umbratorum* (Tonnoir), Edwards, 1931, p. 131; Smart, 1945, p. 499.

*Female*: Small, brown species; thorax not as strongly arched as in *C. aurantiacum*. No propleural hairs. Wing with  $Cu_1$  almost straight (the most distinctive feature of the species—Fig. 4). Calcipala with a distinct notch at base; pedisulcus small. Abdomen brown, with pubescence on dorsum greatly reduced, though still fairly conspicuous at sides.

This species could be allotted to the *aurantiacum* group on venation, possession of a large basal tooth on the claws, and general appearance; but it has other characters which seem to relate it more closely to the *terebrans* group: terminal segment of palp but little longer than penultimate; relatively bare abdomen; relatively short stem of the genital fork, and relatively short, broad paraprocts.

*Distribution*.—Victoria: Fern Tree Gully, Oct., Tonnoir (*type locality*); Beaconsfield, Nov., G. F. Hill.

*Biology*: Known only from females collected by sweeping plants with a net.

#### CNEPHIA TEREBRANS (Tonnoir).

*Simulium terebrans* Tonnoir, 1925, p. 237. Type in Division of Economic Entomology, C.S.I.R., Canberra.

*Cnephia terebrans* (Tonnoir), Edwards, 1931, p. 131; Smart, 1945, p. 499.

*Female*: A small brownish-black species, with dark brown legs. Terminal segment of palp only slightly longer than penultimate. No propleural hairs detected, but specimen rather rubbed. Calcipala well developed; indefinite pedisulcus, and chitin in this area weak; claws with minute tooth near base, distinct from basal projection, so that claw has a double-toothed appearance (Fig. 10). Abdomen dark brown (described by Tonnoir before dissection as having yellow hairs on apical segments and yellow lateral hair tufts).

*Distribution*.—Victoria: Sassafra, Oct., Tonnoir (*type locality*). New South Wales: Canoblas, Oct., E. W. Ferguson.

*Biology*: The type (the only specimen we have seen) was collected biting man.

#### CNEPHIA sp. A.

*Simulium nigrum* Tonnoir MS., *nec Cnephia nigrum* (Rubtzov, 1940), Sharp, 1945, p. 498. Type in School of Public Health and Tropical Medicine, Sydney.

*Female*: Blackish, with dark brown legs. Rather like the eastern *C. fergusonii*, but frons narrower, propleural hairs absent or reduced to a few weak ones at lower margin,

and calcipala well developed. Spinules are present on the costa. Pedisulcus present, though small. Claws with a single, well-developed, basal tooth. Abdomen black; all abdominal hairs dark, except fringe on first segment.

There is no doubt that this species is quite distinct from any other Australian member of the family.

*Distribution*.—Western Australia: Pemberton, Aug., Ferguson, Nicholson; Bridgetown, Aug., Nicholson.

*Biology*: There are no specific notes concerning this species. It was taken in company with *C. fergusonii* var., and may also have been biting man.

#### CNEPHIA FERGUSONI (Tonnoir).

*Simulium fergusonii* Tonnoir, 1925, p. 238; Sharp, 1945, p. 505. Location of type not known; paratypes in School of Public Health and Tropical Medicine, Sydney, and Division of Economic Entomology, C.S.I.R., Canberra.

*Female*: Large, blackish grey, very like a big *Austrosimulium*; legs uniformly brownish black. A group of well-developed propleural hairs present. Wings unusual, in that we have been unable to detect spiniform macrotrichia on the costa. No trace of calcipala nor of pedisulcus; claws without teeth, though the base is distinctly thickened. Abdomen blackish brown, resembling *Austrosimulium cornutum*.

*Distribution*.—New South Wales: Bumberry, Oct., Ferguson (*type locality*). South Australia: Lucindale.

*Biology*: The type series was taken biting man. Tonnoir (MS.) also notes: "A specimen in the collection of the School of Public Health and Tropical Medicine from Lucindale, recorded as severely injuring horses and cattle, may be one of those which were the object of Mr. Lea's note." Lea (1917) had recorded a species of *Simulium* as attacking stock in this locality in South Australia.

#### CNEPHIA FERGUSONI (Tonnoir) VAR.

*Simulium fergusonii occidentale* Tonnoir MS., nec *Simulium occidentale* Townsend, 1891, Smart, 1945, p. 510. Type in School of Public Health and Tropical Medicine, Sydney.

*Female*: Differs from the typical form in being distinctly more greyish in colour, with ashy reflections on thorax, and the legs a much lighter brown. The costa lacks spinules as in the typical form, propleural hairs are present, and there is no pedisulcus, but there is a distinct though minute calcipala (Fig. 10). Claws with a small tooth at base, sometimes appearing to be double.

*Distribution*.—Western Australia: Bridgetown, Ferguson, Nicholson; Narrogin, Nicholson; Tammin, Nicholson. All collected in August.

*Biology*: Some at least of the specimens were taken biting man.

#### The Genus SIMULIUM Latreille.

*Adults*: Antennae eleven-segmented; palpi variable, terminal segment sometimes as long as previous two together; thorax normal; pubescence dense, much of it in the form of lanceolate scales; propleural hairs dense and conspicuous in all species; wing with thorn-like spines among the macrotrichia on C and the greater part of  $R_1$ ; no small cell at base;  $Cu_1$  with a strong double curve; calcipala and pedisulcus well developed in all species; claws of female with or without tooth; abdomen of female densely covered with a mixture of hairs and scales (part of the dorsum is bare and shiny in *S. clathrinum*, but the appearance is quite unlike that of *Austrosimulium*); genital fork of female with relatively long, slender stem; male hypopygium with a single spine on style; anterior part of phallosome nearly or quite smooth ventrally (except on keel of *S. ornatipes*); posterior part differentiated, and possessing variously developed chitinizations; median process seen only in *S. ornatipes*.

*Pupa*: Respiratory organs with relatively few, long, rigid tubes arising from an inconspicuous base.\* Abdomen with sub-basal dorsal spines confined to seventh, eighth, and sometimes ninth segments; dorsal and ventral sub-apical hooks present on some segments; terminal spine small and backwardly directed (Fig. 7).

\* *S. papuense* is exceptional in having a *Cnephia* type of respiratory organ.

*Cocoon*: Finely woven and neatly formed; complete beneath the abdomen of the pupa.

*Larva*: Pupal gill spot with filaments coiled posterior to the main stem (Fig. 19); anal gills simple or compound; ventral papillae present or absent; anterior limb of anal sclerite without backwardly-directed strut. Genotype: *Rhagio colombaschensis* Fabr., Europe (Smart, 1945).

The genus is well defined in the region, and conforms adequately with Old World species. Two groups are recognized on adult characters, but the early stages are diverse and cannot be divided in the same way.

#### The *ornatipes* group.

Pre-alar and lower sternopleural areas bare.

One species, which is a typical *Eusimulium* belonging to Edwards' (1934) subgroup D. *S. aureohirtum* Brun. from India, Java and Sumatra appears to be closely related.

#### SIMULIUM ORNATIPES Skuse.

*Simulium ornatipes* Skuse, 1890, p. 595; Tonnoir, 1925, p. 232; Drummond, 1931, p. 6; Swan, 1937, p. 728; Taylor, 1944, p. 213; Smart, 1945, p. 510; Wharton, 1948, p. 357; Mackerras and Mackerras, 1948, p. 239. Type in Australian Museum, Sydney.

*Chelocnetha biroi* Enderlein, 1936, p. 117. Types in Budapest or Berlin Museum (Wharton, 1948).

*Adult*: Differs from all other Australian members of the genus in the group characters, in the conspicuously marked yellow and black legs, and in having yellow fore and mid coxae. *S. clathrinum* and *S. nicholsoni* occasionally (especially in recently emerged specimens) show leg markings somewhat like *S. ornatipes*, but the coxae are always dark. The male hypopygium is distinctive in having a strong ventral, spinulose median keel on the anterior part of the phallosome.

There is no doubt about the synonymy of Enderlein's species, which was pointed out by Wharton (1948). The description agrees well, and Biro collected in Sydney and New Guinea (Musgrave, 1932), from both of which localities *S. ornatipes* is known.

*Cocoon*: Wall-pocket type, with an irregular, mid-dorsal, anterior projection, and either no collar beneath the head (eastern specimens) or a narrow one (specimens from Western Australia).

*Pupa*: Head and thorax covered with small, flat tubercles. Thorax with four stout, tapering gill filaments on each side. Two forms recognized, one with short filaments (1.4 to 2 mm.) and the other with long filaments (2.5 to 3 mm.); they may occur together.

*Larva*: Robust, dark. Head broad, pattern on dorsum positive type (Fig. 8). Gill spot large, black, conspicuous. Anal gills simple. Ventral papillae present.

*Distribution*.—New Guinea: Moresby district, June, D. J. Lee and R. H. Wharton. Queensland: Rockhampton district; Dawson and Burnett R. watersheds; Brisbane R.; Brisbane; South Coast district; Stanthorpe district; Condamine R. and tributaries; Cunnamulla. Found at various times of year except early summer. New South Wales: Many coastal and tableland streams between Queensland border and Newcastle, Mar. and Aug., D. Mackerras; Gosford, May, D. Mackerras; Oxford Falls, Wharton; Sydney, June, F. A. A. Skuse, Sept., F. H. Taylor, Sep.-Dec., Ferguson; Hartley (Lett R.), Dec.-Jan., Wharton; Bathurst (Fish R.), Apr., Wharton; Glanmire (3,000 ft.), Apr., Wharton; Darling R., Louth (*type locality*), Helms; Bourke; Wilcannia. A.C.T.: Canberra, Molonglo R., Oct.-May, Cotter R., Dec.-Apr., Tonnoir. South Australia: Waterfall Gully, Jan.; Wakefield R., Jan.; Glen Osmond, May; all coll. D. C. Swan. Western Australia: Darling Range area, presumably spring and early summer, Drummond; Dalgarpur Brook, Aug., Nicholson. Not recorded from Victoria or Tasmania.

*Biology*: We have already discussed the biology of this species in some detail (Mackerras and Mackerras, 1948). It is the most widespread and usually the most abundant Simuliid in Australia, but the adults have rarely been seen in nature, and are not known to take blood. Early stages abound in almost every moderate to sluggish, fairly clear stream or channel in which water runs for more than a few weeks, and



have even been found in still rock-pools, into which they were probably washed by a recent freshet (Wharton, personal communication). They prefer submerged grass-blades and other vegetation, but also occur on stones. The duration of the life-cycle in warm weather is probably about three weeks.

Tonnoir had two interesting notes on this species at Canberra.

1. He collected large numbers of males "dancing in swarms at sunset at highest point of Deakin Park, 20 Mar., 1935". This point is more than 1½ miles from the river.

2. "At the end of May, 1931, some larvae were observed in the aquarium with rather small, not always easily detectable *Mermis* worms. These larvae were isolated in breeding cascade and died within a week, the worm increasing to a very large size and turning a dark colour within the last few days. The worm bores a hole in the side of the larva to get out; the larva collapses completely and dies. The histoblasts did not develop, as mentioned by Strickland. Two worms were placed in damp soil in a crystal dish, but, when examined a week afterwards, no trace of them was found."

#### The *clathrinum* group.

Membranous prealar area bearing numerous lanceolate scales; lower sternopleural area with evenly spaced, short, erect hairs. Legs usually with greater part of hind metatarsus pale.

This group appears to be near Edwards' (1934) sub-group C, for he describes the lower sternopleural hairs and the rather characteristic leg markings, though he does not mention the prealar scales. These are so conspicuous (at any rate in fresh specimens) that we doubt whether they could have been present in the Oriental species.\* This character appears to have been used previously only by Gibbins (1934), followed by de Meillon, for the *hirsutum* group in the Ethiopian fauna. His figures, however, indicate a rather different appearance and arrangement of the hairs, and we do not suggest that the *hirsutum* and *clathrinum* groups are faunistically related.

Owing to the close relationship of the adults, longer descriptive notes are necessary than elsewhere in this paper.

#### SIMULIUM CLATHRINUM M. and M.

*Simulium clathrinum* Mackerras and Mackerras, 1948, p. 248. Type in Division of Economic Entomology, C.S.I.R., Canberra.

*Female*: Medium sized, rather thick-set, very dark species. Frons one-seventh head width. Scutum black, with three somewhat indefinite golden lines on disc and creamy reflection at sides. Wings with veins at base black and included membrane infuscated. Legs with conspicuous silvery or creamy scales on femora and tibiae, as well as on pale part of hind metatarsus. Claws with a distinct basal tooth. Abdomen with usual silvery fringe to first segment; second to fourth covered with black scales; remainder shining black dorsally.

*Male*: Upper facets of eyes unusually enlarged, about the size of second antennal segment. Thorax with golden lines as in female. Wings and legs similar to female, but pale scales on femora and tibiae more golden and less conspicuous. Abdomen black, except for sublateral, ashy, shining patches on second, fifth and sixth segments. Hypopygium with anterior part of phallosome without keel and not transversely ridged below, bare on centre, but with some short hairs and spinules laterally.

*Cocoon*: Characteristic; sub-conical, with a distinct anterior collar, which is prolonged all round into a latticed portion surrounding the gill filaments of the pupa (Fig. 20).

*Pupa*: With four long, slender, pointed, dark gill filaments arising from a short, dark stem on each side.

\* Mr. Paul Freeman has informed us that there are no prealar scales or hairs on any of Edwards' species from Java and Sumatra in the British Museum.

*Larva:* Robust, dark. Head with a ventral incisure, pattern positive type, irregular in shape. Gill-spot rather small, pear-shaped. Rectal gills compound. Ventral papillae absent, but ventro-lateral swellings present.

*Distribution.*—Queensland: South Coast district (Lower Mudgeeraba Ck. *type locality*), March, May, June; Brisbane, June; Brisbane R., May; Samford district, April; Gayndah, May; Eidsvoll, May.\*

*Biology:* Early stages on stones, grass blades and sometimes logs in swiftly running, clear water, most numerous where flow most powerful; pupae sometimes in dense masses. Habits in adults unknown.

#### SIMULIUM PAPUENSE Wharton.

*Simulium papuensis* Wharton, 1948, p. 359. Type in Macleay Museum, University of Sydney.

*Female:* Close to *S. clathrinum*, but differs in that the golden scales on the scutum are not concentrated into three longitudinal lines, veins at the root of the wing are paler (brown), and the teeth on the claws, if present, are much smaller. Abdomen with all segments clothed with scales dorsally; first with a creamy gold fringe; second quite densely covered with creamy gold scales; third dark, with a rather scattered apical line of pale scales; fourth with the pale scales more numerous on disc, but still predominantly apical; fifth and sixth with the pale scales fairly evenly diffused over disc; apical segments hidden in the specimens we have seen.

*Male:* The upper eye-facets are even more enlarged than in *S. clathrinum* (Wharton, 1948, fig. 8); otherwise the male is only to be distinguished by the uniform distribution of the golden scales on the scutum. Hypopygium with the anterior part of the phallosome more like that of *S. nicholsoni*, broad, appearing transversely ridged, and very delicately spinulose below.

*Cocoon:* Sub-cylindrical, rounded posteriorly, rather delicate, with a fenestrated collar beneath head anteriorly, and with the lateral margins swept back to expose the greater part of the thorax of the pupa.

*Pupa:* Gill filaments remarkable, strongly arborescent, like those of the species of *Cnephia* described above. The abdominal chaetotaxy is, however, normal and the terminal spines are quite small.

*Larva:* Robust; close to *S. clathrinum*, and is the only other known Australasian species with compound anal gills. Distinguished by the broad, conspicuous, bullet-shaped, median dark stripe on the head (Fig. 8), extremely deep ventral incision of the head capsule (almost reaching the submentum), presence of ventral papillae, and the large gill-spot, which is not as dark as that of *S. ornatipes*. The filaments are coiled in normal *Simulium* fashion (cf. *Cnephia*).

*Distribution.*—New Guinea: Pt. Moresby, June, Lee and Wharton (*type locality*); Milne Bay, Mackerras.

*Biology:* Early stages on stones in small creek with a moderate flow. Habits of adults unknown.

#### SIMULIUM OCULATUM (Enderlein).

*Pselaphochir oculata* Enderlein, 1936, p. 121. Types presumably in Budapest or Berlin Museum (Wharton, 1948).

*Simulium oculata* (Enderlein) Smart, 1945, p. 510; Wharton, 1948, p. 358.

We have not seen this species, but it appears to belong here. The male has greatly enlarged upper eye facets, like *S. papuense*. The female is separable from *S. clathrinum* by the uniformly distributed golden hairs on the scutum and the untoothed claws, and from *S. papuense* by the rather smooth, black (apparently bare) last three abdominal tergites. Enderlein does not mention any pale zone on the hind metatarsus, which may be a distinguishing character in both sexes.

*Distribution.*—New Guinea: Sattleburg (Huon Gulf), Nov., Biro (*type locality*).

\* Mr. Wharton has discovered a closely related species in the Blue Mts. and Sydney District, N.S.W.

## SIMULIUM WILHELMLANDAE Smart.

*Wilhelmia pygmaea* Enderlein, 1922, p. 70 (*nec Simulia pygmaea* Zetterstedt, 1838). Type possibly in Budapest or Berlin Museum (Wharton, 1948).

*Morops pygmaeus* Enderlein, 1930, p. 93; Edwards, 1934, p. 118.

*Simulium wilhelmlandae* Smart, 1944, p. 131 (*nom. nov.*); Wharton, 1948, p. 358.

*Male*: We have not seen this species, but it almost certainly belongs here, for it has the upper facets of the eye greatly enlarged, mesosternal hairs, and the characteristic colouration of the hind metatarsus (Edwards, 1934). It should be easy to recognize by its bright brown-yellow antennae and yellow-ochre first two segments of the abdomen.

*Distribution*.—New Guinea: Kaiser Wilhelmland (= Mandated Territory of New Guinea), Hollsong (*type locality*).

## SIMULIUM NICHOLSONI M. &amp; M.

*Simulium nicholsoni* Mackerras and Mackerras, 1948, p. 251. Type in Division of Economic Entomology, C.S.I.R., Canberra.

*Female*: A rather small, dark species, more slender than *S. clathrinum*, and with frons one-fourth head width. Antennae with first two segments and base of third brownish yellow, remainder deep brown. Scutum with numerous pale scales, which are golden towards the centre, more silvery at the sides, and with dark, converging dorso-central lines; shoulders almost black; pleurae dark man-o'-war grey, with but faint indications of ashy reflections, the only brown part being the membranous prealar area; prealar scales silvery. Wings with veins at root yellowish to brown. Legs with silvery scales on femora and tibiae, hind metatarsi largely pale; claws humped at base but not toothed. Abdomen covered with brownish black scales; fringe of first segment with silvery reflections; second with an apical, transverse silvery band; third and fourth dark medially, with silvery apical patches laterally; subsequent segments with sprinkling of pale scales on disc as well as the lateral silvery zones.

The general appearance of this species is silvery and black.

*Male*: A black species, with ashy lateral patches on the abdomen. Bears a superficial resemblance to the males of *A. bancrofti* and *A. pestilens*, from which it is to be distinguished by the generic and group characters. It is to be separated from *S. clathrinum* by lacking the golden thoracic lines, and on rubbed specimens by the hypopygium, the anterior part of the phallosome being relatively broader, with distal edge curled backwards (giving the appearance of a transverse ridge) and very delicately spinulose ventrally.

*Cocoon*: A simple, finely woven wall-pocket, without anterior collar or dorsal projection.

*Pupa*: With six, rather narrow, straight gill-filaments arising from a slender stem on each side, directed forward and lying close together in a characteristic fashion.

*Larva*: Rather delicate, characteristically yellowish in colour. Head pattern of negative type (Fig. 8). Gill spot small, pear-shaped. Anal gills simple; ventral papillae present.

*Distribution*: Queensland: Many localities from the South Coast and Brisbane districts to the Mackenzie R. (Fitzroy watershed) and westward to Dalby (Condamine watershed). The *type locality* is Brisbane R. (Wivenhoe). Collected from April to June and again in January. New South Wales: Bathurst (Fish R.), Apr., Wharton.

*Biology*: Common and widespread, but the adults have rarely been seen, most being collected by sweeping *Metaleuca* in creek beds, and an occasional specimen while making half-hearted attempts to bite man (E. N. Marks). Early stages in moderately fast, fairly clear to somewhat muddy water, usually attached to submerged vegetation, dead sticks, and leaves or logs. Its place in the succession of species which follow flooding is between *A. bancrofti* and *S. ornatipes* (Mackerras and Mackerras, 1948). It must have a resistant stage to carry it through periods of drought.

## SIMULIUM FAHEYI Taylor.

*Simulium faheyi* Taylor, 1927, p. 71; Sharp, 1945, p. 504; Mackerras and Mackerras, 1948, p. 255. Type (labelled "Allotype") in School of Public Health and Tropical Medicine, Sydney.

*Female*: Close to *S. nicholsoni*, but the general colouration is brown or grey and golden rather than black and silvery. In particular, the prealar scales are creamy to golden, the legs are brown with pale golden scales, and the dark scales on the dorsum of the abdomen are a rich brown in colour. The shoulders are brown, the colour extending down on to the pleura in a patch behind the pronotal lobes and posteriorly in a narrow zone around the anterior spiracle to join the brown prealar area. The remainder of the pleural surface is pale grey with distinct ashy reflections, so that there is a contrast in colours which is not seen in *S. nicholsoni*. The claws were described by Taylor as toothed; the basal thickening is pointed in the type (forming an indication of a tooth) but not in the other specimens we have seen.

*Distribution*.—Queensland: Innisfail, Taylor (*type locality*); Lawn Hill (near Burketown), May, Mackerras. Northern Territory: Brocks Ck., Apr., T. G. Campbell; Adelaide R., March, A. R. Woodhill.

*Biology*: The type was taken by sweeping vegetation along a creek. Campbell notes his specimens as giving a severe bite.

#### SIMULIUM sp. B.

*Female*: A single specimen of the *clathrinum* group from the Northern Territory is new to the region. It is very small (body 1.3 mm.). Frons one-third of head width; antennae light fawn throughout. Thorax grey, with silvery scales. Wing with light cream veins and hairs, but black spinules on C and R<sub>1</sub>; R appears to be bare (a unique character in the region), but the pale hairs of this species are exceedingly difficult to detect without mounting a wing. Legs with the greater part of mid and hind femora and tibiae and of hind metatarsus pale yellow; claws without teeth. Abdomen with basal four segments brown dorsally, covered with brown and some golden scales; remainder grey, tomentose, with rather scattered creamy scales.

This species should be easy to recognize, when material adequate for naming it is discovered. Its nearest relative may be *S. wilhelmlandae* from New Guinea.

*Distribution*: Northern Territory: Adelaide R., Mar., Woodhill.

#### The Genus AUSTROSIMULIUM Tonnoir.

*Adults*: Small to medium, dark or greyish species; antennae ten- (occasionally nine-) segmented; palpi with terminal segment about two-thirds as long as previous two together; thorax normal; pubescence short, fine; propleural hairs present or absent, never conspicuous; wings with spines among the macrotrichia on costa, but none on R<sub>1</sub>; small cell present, though often poorly defined; Cu<sub>1</sub> with a strong double curve; calcipala and pedisulcus well developed in all species; claws of female usually simple, sometimes with a strong tooth at base; abdominal pubescence of female short and scanty, so that the dorsum appears either bare but rather dull, or covered with delicate, velvety tomentum; genital fork of female with stem relatively short and broad; male hypopygium with three (occasionally four or two) spines on style; ventral surface of anterior part of phallosome strongly swollen and setulose; posterior part membranous, often swollen, armed with groups of delicate, pale denticles; median piece sometimes lightly chitinized, usually impossible to detect.

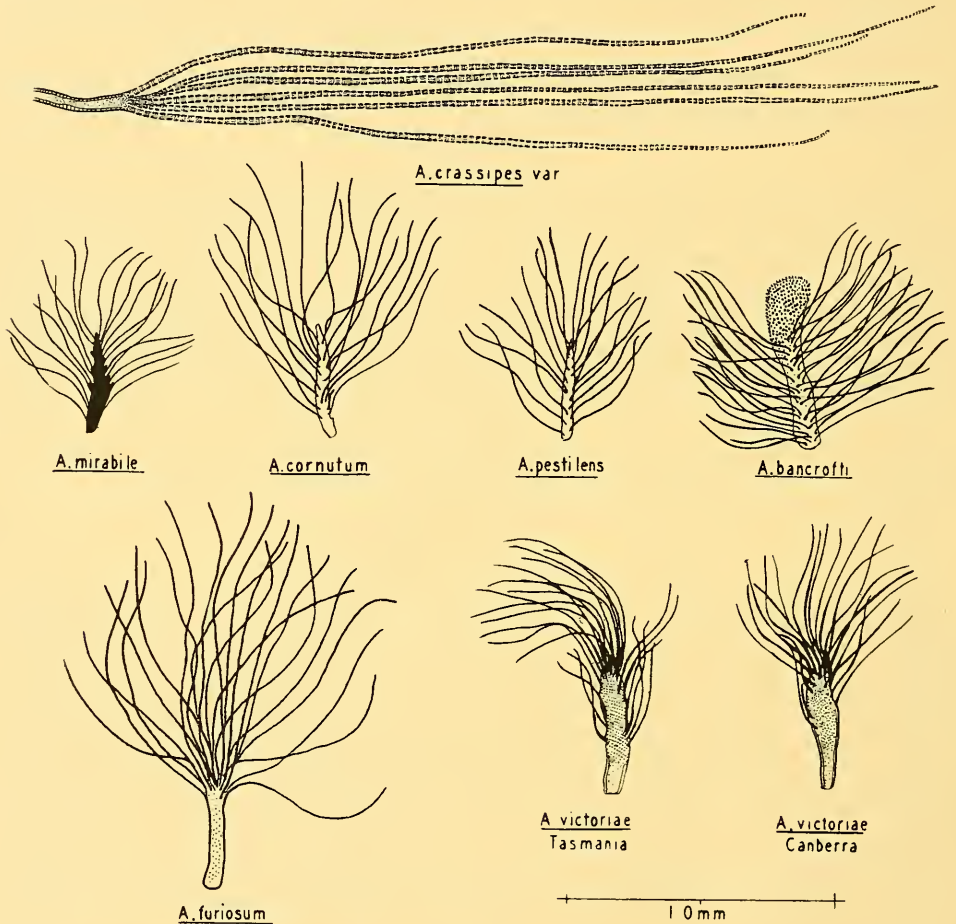
*Pupa*: Respiratory organ (Fig. 12) usually characteristic, a clavate, tapering, or spatulate horn bearing numerous fine, unbranched filaments,\* which appear as if composed of a large number of short, delicate segments. Abdomen with no sub-basal dorsal spines on any segment; sub-apical dorsal hooks present on a variable number of segments; sub-apical ventral hooks usually absent; terminal spines small, backwardly or inwardly directed (Fig. 7).

*Cocoon*: Finely woven and neatly formed; deficient ventrally in its hinder part, so that the abdomen of the pupa lies on the substrate.

\* *A. crassipes* (Fig. 12) and two New Zealand species have a relatively short stem and fewer, longer, wider filaments.

*Larva*: Pupal gill-spot with filaments curving anteriorly and upwards from the main stem; anal gills simple; ventral papillae present or absent; anterior limbs of anal sclerite each with a slender, backwardly-directed strut (Figs. 9, 18)—this feature immediately distinguishes *Austrosimulium* larvae from those of any other genus in the region, though it is figured by Gibbins (1934) in two Ethiopian species of *Simulium*; in some species an incomplete chitinous strut encircles the tip of the abdomen ventral to the posterior limb of the anal sclerite.\*

Genotype: *Simulium australense* Schiner, from Auckland, New Zealand, by original designation (Tonnoir, 1925, p. 230).



Text-fig. 12.—Pupal respiratory horns of Australian species of *Austrosimulium*.  
(For *A. torrentium* see Fig. 18.)

*Austrosimulium* is the best differentiated genus in the region, and is easily recognizable at all stages. In lacking spines on  $R_1$  and possessing a small cell, it would appear to lie closer to the *Prosimulium* complex than to *Simulium*. The *terebrans* group is a possible link in *Cnephia*. Also, Puri (1926) has described the pupal breathing horn

\* An almost complete ring is formed by the posterior limbs and this strut, and it lies immediately anterior to the posterior circlet of hooks. Its position was mistaken by Sharp (1945, footnote to p. 486), who apparently thought that the ring was formed in relation to the anterior limbs of the anal sclerite.

of *Prosimulium ferrugineum* as resembling the *Austrosimulium* type, while Edwards (1931) has pointed out that the ventral arms of the anal sclerite of the larva surround the tip of the abdomen only in *Gigantodax* and some species of *Austrosimulium*.

AUSTRALIAN SPECIES.

Three groups are recognized on female and larval characters. Pupae are diverse.

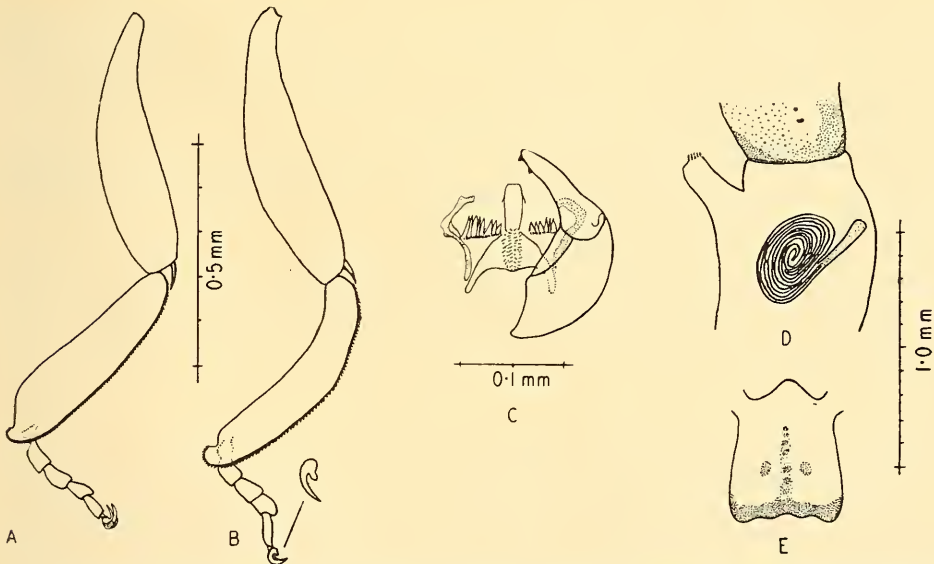
The *mirabile* group.

Claws of female strongly toothed; abdomen various. Larva with incomplete, dark, chitinous ring surrounding tip of abdomen anterior to circle; ventral papillae present. Shows relationship with New Zealand species.

AUSTROSIMULIUM MIRABILE M. & M.

*Austrosimulium mirabile* Mackerras and Mackerras, 1948, p. 266. Type in Division of Economic Entomology, C.S.I.R., Canberra.

*Adult*: Both sexes are easily recognized by the very long, dark antennae, with an orange band covering segments four to six, and by the presence of three dark spots in the radial field of the wing. Dorsum of abdomen with ashy, tomentose markings in both sexes, supplemented by patches of brilliant white scales in female. Style of male hypopygium with only two teeth.



Text-fig. 13.—A. *crassipes* var. A. Leg of male. B. Leg of female, with enlarged claw to show tooth characteristic of group. C. Hypopygium of male. D. Gill-spot of larva. E. Head pattern of larva.

*Cocoon*: Wall-pocket type, often flattened at sides and almost circular in dorsal view; without collar, and with a small, mid-dorsal, anterior projection.

*Pupa*: Respiratory horn black, pointed, covered with longitudinal spiny ridges. Numerous filaments, about as long as the horn, arise from the furrows between the ridges.

*Larva*: Distinguished from relatives only by the characters given in the key, and the gill-spot which is elongate-oval and conspicuous by reason of the jet-black respiratory horn.

*Distribution*.—Queensland: Dawson Ck. on slopes of Mt. Glorious, Apr. (*type locality*).

*Biology*: Early stages on dead leaves in moderately fast, clear water. Habits of adults unknown.

## AUSTROSIMULIUM CRASSIPES Tonnoir.

*Austrosimulium crassipes* Tonnoir, 1925, p. 242; Smart, 1945, p. 499. Type in Division of Economic Entomology, C.S.I.R., Canberra.

Mr. R. H. Wharton has recently collected the early stages and bred out adults in the Blue Mountains, New South Wales. His males conform well to the hitherto unique type, including the details of the hypopygium, and differ only in that the hind metatarsus is not so incrassate. We feel that these specimens should be regarded at most as a geographical race of *A. crassipes*, but an element of doubt must remain until the early stages are discovered in Victoria. The notes below are based mainly on Mr. Wharton's material.

*Female*: A dark species, with unusually long creamy-yellow hairs on scutum and legs, and entirely dull, brownish black abdomen. Generally like a small *A. cornutum*, but the hind metatarsus is wider and the calcipala differently shaped (cf. Figs. 13B and 15).

*Male*: Immediately distinguished by the incrassate hind metatarsus (Fig. 13A, cf. also Tonnoir, 1925, Fig. 2, I). The style of the hypopygium has only two teeth; the setulose area on the anterior part of the phallosome is more restricted than usual; the posterior part bears a row of long, though delicate, teeth on each side; and the large median piece can be distinctly seen (Fig. 13C).

*Cocoon*: Similar to *A. mirabile*, but with a narrow collar, and sometimes a larger dorsal projection (Fig. 20).

*Pupa*: Distinguished by the six remarkably long gill filaments arising from a short stem, the whole respiratory organ being as long as the cocoon. Superficially a relationship to *S. nicholsoni* might be suggested, but the segmented appearance of the filaments (Fig. 12) is an *Austrosimulium*, not a *Simulium* character.

*Larva*: Younger larvae resemble *A. mirabile* closely, but the dorsal ends of the chitinous ring are not expanded (cf. Fig. 9), and the number of teeth per row in the circlet is 15–20 as compared with 12–15. Gill-spot unique in the genus by reason of the evenly coiled filaments (Fig. 13D).

*Distribution*.—Victoria: Sassafras, Oct., Tonnoir (*type locality*). New South Wales: Mt. Victoria, December–March; Wharton; Wentworth Falls, Mar., Wharton.

*Biology*: Tonnoir's specimen was collected by sweeping vegetation along a creek. Mr. Wharton's larvae were found on leaves and the pupae on stones in small mountain streams.

## AUSTROSIMULIUM CORNUTUM Tonnoir.

*Austrosimulium cornutum* Tonnoir, 1925, p. 243; Smart, 1945, p. 499. Type in Division of Economic Entomology, C.S.I.R., Canberra.

*Female*: A relatively large, dark species, like *A. victoriae*, but immediately distinguished by the strongly toothed claws. Frons about one-quarter head width; antennae long (as in *A. victoriae*, Fig. 17A); legs rather uniformly brown; calcipala nearly as wide as metatarsus; abdominal tergites dull brown, without trace of black tomentum.

*Male*: Recognizable from other dark species only by the wide calcipala. There are two teeth on the style of the hypopygium, as in *A. crassipes*.

*Cocoon*: Oval, apparently without collar, but with a single, long, median, dorsal projection "curving downwards so as to protect the head of the nymph" (Tonnoir).

*Pupa*: Respiratory horn strong, brown, tapering, with numerous filaments arising all over surface. It is rather like that of *A. mirabile*, but the horn is not black and not so ridged.

*Larva*: Distinguished from its relatives only by the characters listed in the key, and by the S-shaped gill-spot rather like that of *A. furiosum* (Tonnoir, 1925). The basal segment of the antenna, though longer than in *A. mirabile*, is still markedly shorter than the distal segment (Fig. 16).

*Distribution*.—Tasmania: Burnie, Oct.; St. Patrick R., Nov.; National Park, Dec.; King R., Feb.; Strahan, Feb.; Mt. Wellington; Cradle Mt.; Eagle-Hawk Neck, Nov.; Maria Is., Nov.

Victoria: Sassafras, Oct. (*type locality*). New South Wales: Mt. Kosciusko (Sawpit Ck., Pretty Pt. Ck.), Dec.; Fitzroy Falls, Nov.; Wentworth Falls, Nov. A.C.T.: Coree Ck., Sept., L. Graham. All but the last coll. Tonnoir.

*Biology*: Adults collected by sweeping, not observed to bite. Early stages in very swift water, rather scattered, never in colonies (Tonnoir).

#### AUSTROSIMULIUM sp. C.

*Female*: Only a single specimen known. Related to *A. cornutum*, having the same type of claws with a powerful tooth at base, but differs in its smaller size, narrower frons (one-eighth of head width), fawn-coloured legs, and in having velvety black abdominal tergites 2-6, which are like those of *A. furiosum* but smaller. A well differentiated species, but we lack the material to describe it adequately.

*Distribution*.—Western Australia: Pemberton, Aug., Nicholson.

#### The *bancrofti* group.

Claws of female simple; abdomen with ashy central patches, forming a median dorsal stripe. Larva without chitinous ring; ventral papillae absent.

#### AUSTROSIMULIUM BANCROFTI (Taylor).

*Simulium bancrofti* Taylor, 1918, p. 168; Taylor, 1927, p. 70 (part). Type female (labelled "Allotype") in School of Public Health and Tropical Medicine, Sydney.

*Austrosimulium bancrofti* (Taylor), Tonnoir, 1925, p. 241 (part); Drummond, 1931, p. 8; Smart, 1945, p. 499; Mackerras and Mackerras, 1948, p. 256. An allotype male, from Serpentine, Western Australia, was labelled by Drummond, and placed in Division of Economic Entomology, C.S.I.R., Canberra.

*Female*: A medium to small, greyish species. Antennae nine-segmented, third segment enlarged (Fig. 1); first two segments creamy yellow. Abdomen with a wide, discontinuous, ashy dorsal stripe, distinguishing this species from all others except *A. pestilens*. Legs with considerable pale fulvous suffusion.

*Male*: Black. Antennae nine-segmented. Abdomen with a conspicuous patch of ashy tomentum laterally on fifth and sixth segments. Hypopygium with style distinctly longer than coxite.

*Cocoon*: Shoe-shaped, with a conspicuous anterior collar, which is deeper than in any other species. The opening is well swept back, and there is no mid-dorsal projection.

*Pupa*: Respiratory horn flat, spatulate. The filaments are about as long as the horn, and arise from the whole of the outer surface except the distal fourth, which is spinulose.

*Larva*: Head usually fairly heavily pigmented; submental teeth seven. Gill-spot elongate, club-shaped (very characteristic). Anal armature with anterior limbs forming less than a right-angle. Posterior circler with 20-30 spines per row.

*Distribution*.—Queensland: Mackenzie, Dawson and Burnett R. basins (*Eidsvold type locality*); Brisbane R.; Brisbane; South Coast; Dalby; Chinchilla; Goondiwindi, J. L. Wassell; Roma, R. A. J. Meyers. Collected between March and August. New South Wales: Hartley (Lett R.), Dec., Wharton; Bathurst (Fish R.), Apr., Wharton; Bumberry, Oct., Ferguson\*; Bourke, May, Ferguson\*; Yass, Aug., Nov., K. English. A.C.T.: Molonglo R., Sept.-Apr., Tonnoir; Black Mt., June, Hill, Nov., F. J. Gay; Cotter R., Nov.-Apr.; Murrumbidgee R., Jan.; Blundell's, Sept., Dec., Feb., Tonnoir; Lee's Spring, Oct., Hill; Brindabella, Oct., L. Willings. Tasmania: Launceston, Apr., M. Crust. Western Australia: Darling Range area, spring and early summer, Drummond; Serpentine, Apr., Drummond; Mundaring, Aug., Ferguson; Bridgetown, Aug., Nicholson. Not yet known from Victoria or South Australia.

*Biology*: Been taken biting man, more frequently in the southern and western parts of its range than in Queensland. Early stages in very fast-moving, fairly clear to definitely muddy water; usually attached to submerged *Melaleuca* fronds, sticks, logs, dead leaves, and occasionally stones. Larvae crowd together in dense masses. Comes next after *A. pestilens* in the succession which follows flooding of inland streams. Must possess a drought-resistant stage.

\* Identification not confirmed; could have been *A. pestilens*.



## AUSTROSIMULIUM PESTILENS M. &amp; M.

*Simulium bancrofti* Taylor, 1927, p. 70 (part).

*Austrosimulium bancrofti* (Taylor), Tonnoir, 1925, p. 241 (part).

*Austrosimulium pestilens* Mackerras and Mackerras, 1948, p. 260. Type in Division of Economic Entomology, C.S.I.R., Canberra.

*Female*: Very close to *A. bancrofti*, from which it is to be distinguished primarily by the ten-segmented antennae. Also, it is usually smaller, the head is distinctly narrower, the basal segments of the antennae are darker, the third segment is smaller, and the legs are more uniformly brown.

*Male*: Only separable from *A. bancrofti* by the ten-segmented antennae and the style of the hypopygium not being quite as long as the coxite.

*Cocoon*: Collar not as high as in *A. bancrofti*, often quite low, but the shape is variable owing to the general crowding together of the cocoons.

*Pupa*: Respiratory horn slender, pointed (cf. the spatulate horn of *A. bancrofti*), with irregular surface, from the whole of which the slender filaments arise; they are a little longer than the horn. *A. cornutum* and *A. mirabile* have similar respiratory organs, but the horn of the latter is dark, and both have ventral spines on the abdomen, whereas there are only ventral hairs in *A. pestilens*.

*Larva*: Head very pale, with only a trace of median marking. Submental teeth eleven. Gill-spot small, oval. Anal armature with anterior limbs diverging at more than a right-angle. Posterior circlet with 10-12 spines per row.

*Distribution*.—Queensland: Widespread from Wowan in Central Queensland to the New South Wales border near Dirranbandi, and inland to Windorah. Not known from east of the Divide, except on the Dawson and Upper Burnett Rivers. Collected from January to April. (Chinchilla *type locality*). New South Wales: Not recorded, but almost certainly present in north-western districts.

*Biology*: This species is the pest Simuliid of Queensland, and its behaviour has already been discussed (Mackerras and Mackerras, 1948). The adults swarm after floods and attack kangaroos, domestic animals and man. The early stages are only found in very fast, turbulent, muddy water. There is an association with *Melaleuca* spp.; the early stages crowd on the submerged parts and cocoon in dense masses on the fronds, while the adults rest in thousands on the exposed parts of the trees. It is first in the succession of species which follows flooding, and evidently has a drought-resistant stage to tide over the periods when the streams are sluggish or dry.

The *furiosum* group.

Claws of female simple; abdomen entirely dark. Larva without chitinous ring; ventral papillae present.

This is a group of species, which Tonnoir considered easy to recognize in the pupal stage, but difficult to separate as adults. We have been unable to distinguish satisfactorily between the males, but the females are better differentiated, and the three types recognized (and these only) could be correlated with well-defined pupal characters. In brief: *furiosum* has the abdominal tergites velvety black; *victoriae* is longer, darker, with relatively long antennae (Fig. 17A; *A. furiosum* is similar); *torrentium* is more compact, greyish, and with distinctly shorter antennae (Fig. 17B; the relative length is similar in *A. bancrofti* and *A. pestilens*). The basic characteristics of the pupae are constant in the three species, but they show some variation in such features as the lengths of the horn and filaments. We are unable to accept these relative differences as justifying specific or subspecific recognition, unless they are accompanied by differences in other stages also.

## AUSTROSIMULIUM FURIOSUM (Skuse).

*Simulium furiosum* Skuse, 1888, p. 1362. Type in Macleay Museum, University of Sydney.

*Austrosimulium furiosum* (Skuse), Tonnoir, 1925, p. 239; Smart, 1945, p. 499; Mackerras and Mackerras, 1948, p. 264. Allotype male, morphotype larva and pupa, from Gosford, March.

D. Mackerras, in Division of Economic Entomology, C.S.I.R., Canberra.

*Austrosimulium simile* Tonnoir, 1925, p. 249. Type in Division of Economic Entomology, C.S.I.R., Canberra.

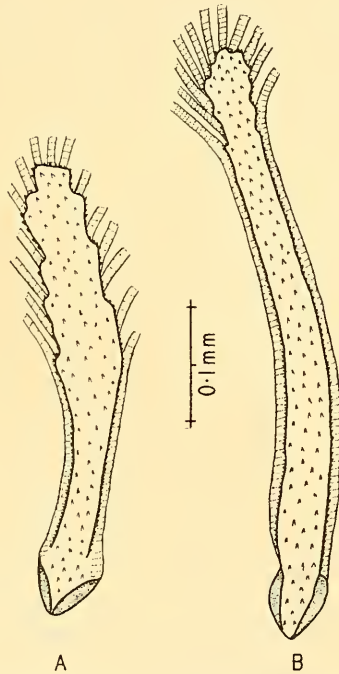
*Austrosimulium austrosimile* Smart, 1944, p. 133.

*Austrosimulium weindorferi* Tonnoir, 1925, p. 248. Type in Division of Economic Entomology, C.S.I.R., Canberra.

*Female*: A medium-sized, dark species; frons about one-fourth head width; antennae long (Fig. 1); propleural hairs present or absent; legs brown, often with darkened tips to femora, tibiae and metatarsi; calcipala from half to two-thirds width of metatarsus; abdomen dark brown or greyish, tergites 2 to 6 velvety black, showing up as conspicuous black patches against the dull ground colour; the posterior edges of the tergites are sometimes narrowly banded with ashy tomentum.

*Male*: Rather small, black, undistinguished. Scutum velvety black, with dark golden hairs; abdomen velvety black; legs darker than in female. Calcipala about two-thirds the width of the metatarsus, and third antennal segment nearly twice as long as the fourth. Style of hypopygium with three teeth; posterior part of phallosome with a row of denticles on each side of distal margin.

*Cocoon*: Simple wall-pocket, with the sides just meeting in front, and no central dorsal projection.



Text-fig. 14.—Pupal horns of *A. furiosum*, showing range of variation.

*Pupa*: The respiratory horn is a slender, rather pale, finely spinulose cylinder, ending distally in an irregularly conical prolongation, from which 20 to 30 slender filaments arise. The filaments are banded with exceedingly minute spines, giving them rather the appearance of striated muscle fibres. Usually the horn is about six times as long as wide (Figs. 12, 14B) and the filaments about twice as long as the horn, but both may be shorter.

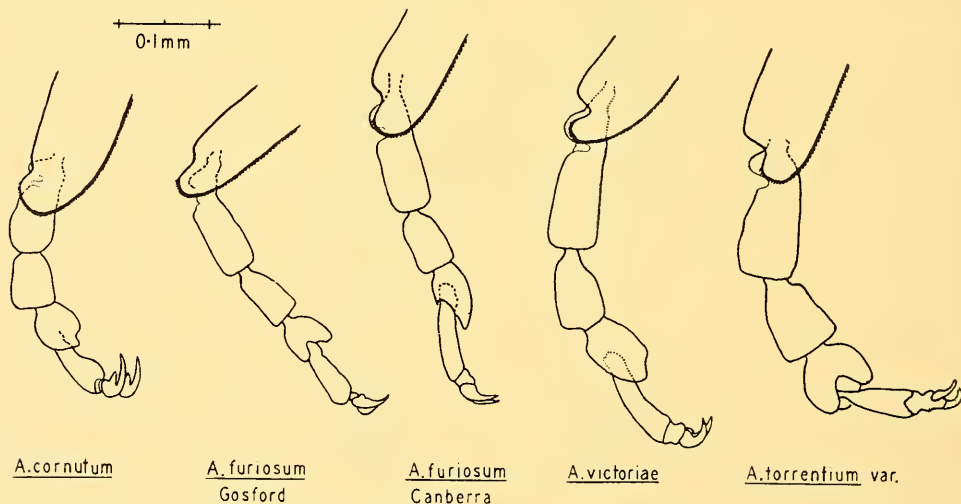
*Larva*: Antennae pale, distal segment\* about as long as basal. Head with an irregular central pattern, and a sublateral dark spot on each side (a useful character for

\* Actually the antennae of Simuliid larvae appear to be four-segmented, the stouter first and second being more or less fused together, the third long and slender, and the fourth very short. We have followed custom and convenience in amalgamating the first and second pairs.

preliminary, low-power diagnosis). Gill-spot S-shaped (cf. *A. cornutum*). Anal sclerite delicate.

*Synonymy*: Our identification of *A. furiosum* is based on fresh material (larvae, pupae, bred adults) collected at Gosford by D. Mackerras, the females being compared with Skuse's type material by Mr. R. H. Wharton. There is no doubt of the identity of Tonnoir's *A. simile* with this species. Smart's *austrosimile* was a *nom. nov.*, as *simile* was preoccupied in *Simulium*. *A. weindorferi* Tonn. differs only in the shorter pupal respiratory horn and filaments (Fig. 14A). Structurally, however, both horn and filaments are exactly the same in the two, as are the larvae and adults. We have seen a few "short-horned" *A. furiosum* from Queensland (cf. also *S. ornatipes*), and feel that *A. weindorferi* is only a variant which does not merit subspecific status.

*Distribution*.—Queensland: Noosa, Aug., Marks; Nerang, Mar., authors; Mudgeeraba Ck., May, authors; Logan R., June, Marks; Dalby, Apr., authors. New South Wales: Armidale, Aug., D. Mackerras; Carlisle's Gully (N. of Tamworth), Aug., D. Mackerras; Gosford (*type locality*), Aug.-Sept., Skuse, Mar. and May, D. Mackerras; Berowra, Aug.-Sept., Skuse; Hartley (Lett. R.), Dec., Wharton; Bathurst (Fish R.), Apr., Wharton; Oberon (Fish R., 4,000 ft), Apr., Wharton; Wentworth Falls, Mar., Wharton; Tallong, Sept., Taylor; Deniliquin, Nov., Ferguson. A.C.T.: Molonglo R., Sept.-Nov.; Black Mt., Oct., Cotter R., Oct.-Dec.; Cotter-Murrumbidgee Junction, Oct.; Murrumbidgee R., Jan.; Blundell's, Jan., Feb., Apr., Graham; Lee's Spring, Nov., Hill; all but last two coll. Tonnoir. Victoria: Morrison's; Cockatoo, Oct.; Fern Tree Gully, Dec.; Beaconsfield, Nov.; all coll. Hill; Sassafras, Oct., Tonnoir. Tasmania: Launceston (Cataract Gorge); Geeveston, Dec.; Bruny Is., Jan.; Cradle Valley, Jan.; Eaglehawk Neck, Nov.; Brown R., Dec.; all coll. Tonnoir. South Australia: Meadows, Aug., Swan. Western Australia: Pemberton, Aug., Ferguson, Nicholson; Kirup, Aug., Nicholson; Walgarup Brook, Aug., Nicholson.



Text-fig. 15.—Tarsi of *Austrosimulium* spp., females.

*Biology*: The full distribution has been given above, because this is a widespread though usually unrecognized species. The adults are apparently cryptic; Swan notes the South Australian specimens as biting man, and those collected by Skuse were presumably biting, otherwise the name is difficult to understand. The early stages are nearly always sparse, only a few specimens being found in any one locality at any one time. They prefer moderately fast, clear, shallow water, but may persist for a while when the flow has been considerably reduced. They are usually attached to vegetation.

#### AUSTROSIMULIUM VICTORIAE Roubaud.

*Simulium victoriae* Roubaud, 1906, p. 521. Type in British Museum, London.  
*Austrosimulium victoriae* (Roubaud), Tonnoir, 1925, p. 240; Smart, 1945, p. 499.  
*Austrosimulium tasmaniense* Tonnoir, 1925, p. 245. Type in Division of Economic Entomology, C.S.I.R., Canberra.

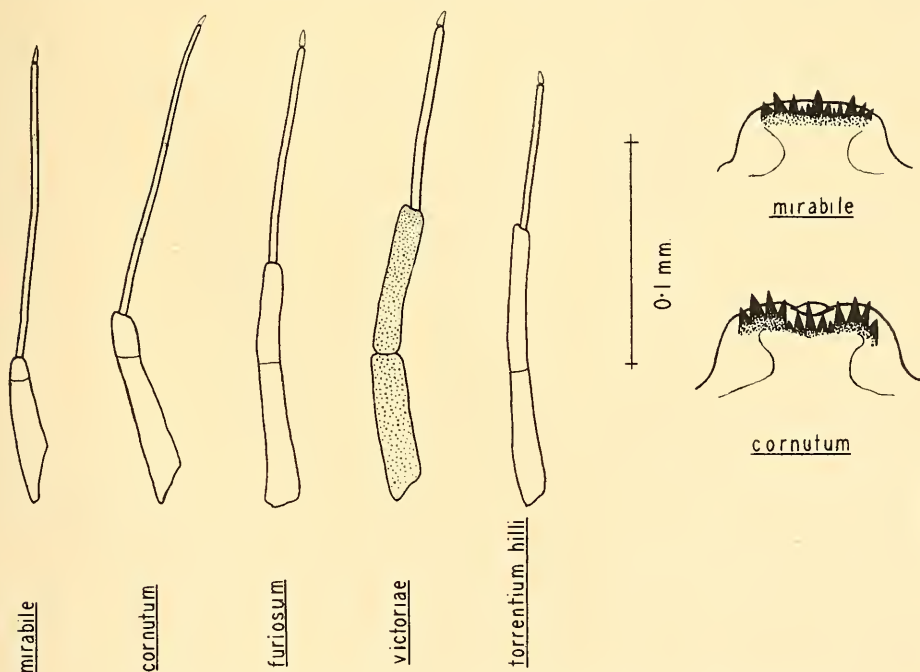
*Female*: A medium-sized, relatively long-bodied, uniformly dark species. Frons about one-quarter head width; antennae long (Fig. 17A); scutum very dark; propleural hairs present or absent; legs uniformly brown; calcipala a little more than half width of metatarsus (Fig. 15); abdominal tergites dull brown, not tomentose.

*Male*: Similar to *A. furiosum*.

*Cocoon*: Elongate oval, with a narrow collar, and distinguished from all other species by having two long, dorsal projections which curve downwards and inwards to cover the respiratory horns of the pupa. Tonnoir's notes suggest that Canberra specimens may have only a single, long, dorsal projection, like that of *A. cornutum*, but the material now available is too fragmented to be certain of this point.

*Pupa*: Respiratory horn rather long and somewhat flattened, the relatively short filaments being inserted along its edge and curved inwards in a characteristically formed tuft. The horn in mainland specimens is broader in the middle (Fig. 12) than in those from Tasmania, but the two are otherwise similar.

*Larva*: Easily recognizable by the dark brown to blackish basal segment of the antennae, all other species known to us having entirely pale antennae. Otherwise very like *A. furiosum*, but with a more robust anal sclerite. The gill-spot is, however, more like that of *A. bancrofti*, so full-grown larvae are easily identified.



Text-fig. 16.—Antennae of larvae of *Austrosimulium* spp., and submental plates of two spp.

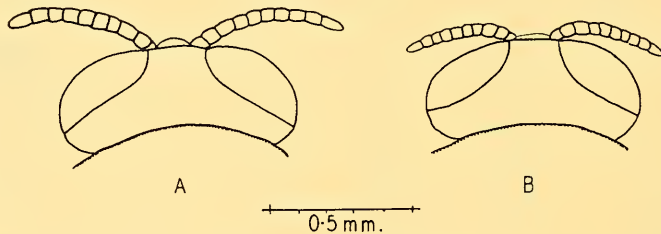
*Synonymy*.—A female in the School of Public Health and Tropical Medicine, bearing a label "Mts. of Victoria, 15.vii.1899, C. French, 1900.171", and identified by Roubaud in 1906 as *Simulium victoriae* Roub., proved to be exactly similar to *A. tasmaniense* Tonn., as recognized from Tonnoir's original series. We sent an inquiry to Mr. Paul Freeman of the British Museum, who was kind enough to give us the following reply:

"Roubaud in his original description refers to 'a number of females'. We have five females, all bearing exactly the same labels as the specimen referred to by yourself as collected by French in 1899 and identified by Roubaud in 1906 as *S. victoriae*. One of ours bears a type label, the others are presumably paratypes. There is no doubt at all

in my mind but that you have one of the same series and that yours is also a paratype. However, on examination, one specimen was seen to be different and is in fact a female of *Cnephia umbratorum*; the other four appear to be one species. We have also two paratypes of *Austrosimulium tasmaniense*: Edwards has placed them beside *A. victoriae* and put a query on the label below Tonnoir's species. I can see no difference whatsoever between these two species. The claws in *victoriae* are simple and therefore it cannot be *cornutum*. The abdomen is uniformly velvety-black and the calcipala between a half and two-thirds width of metatarsus, and it therefore fits *tasmaniense* and not *furiosum* or *torrentium*. Unfortunately we have no specimens of *furiosum* or *torrentium* in the collection, so I am quite unable to compare them, but there seems to be little doubt that *tasmaniense* is the same as *victoriae*."

*Distribution*.—Tasmania: Cradle Valley, Jan.; St. Patrick's R., Oct.-Nov.; Mt. Wellington, Nov.; Brown R., Dec.; National Park, Dec.; Geeveston, Dec.; Hartz Mts., Dec.; Mt. Field, Dec.; all coll. Tonnoir. Victoria: "Mts. of Victoria", July, French (*type locality*); Mt. Buffalo, Oct., R. J. Tillyard and G. A. Currie. New South Wales: Mt. Kosciusko (The Creel, Diggers Ck., Sawpit Ck.), Dec., Tonnoir, Mackerras; Wentworth Falls, Mar., Wharton. A.C.T.: Black Mt., June, Hill; Molonglo R., Sept.-Oct.; Cotter R., Sept.-Oct.; Blundell's, Nov.; Condor Ck., Oct., Hill and J. W. Evans; all coll. Tonnoir except first and last.

*Biology*: Tonnoir took females flying round him but not biting. The early stages were mostly found on stones, occasionally on grass-blades, in small to medium-sized creeks with only a moderate flow of water (Tonnoir).



Text-fig. 17.—Heads of A: *A. victoriae*, and B: *A. torrentium hilli* (both specimens from A.C.T.); dorsal view, to show relative lengths of antennae.

#### AUSTROSIMULIUM TORRENTIUM TORRENTIUM Tonnoir.

*Austrosimulium torrentium* Tonnoir, 1925, p. 247; Smart, 1945, p. 499. Type in Division of Economic Entomology, C.S.I.R., Canberra.

*Female*: A small, compact, greyish species. Frons one-third of head width; antennae (Figs. 1, 17B) distinctly shorter than vertical length of head, basal two segments bare and a lighter brown than remainder. Scutum grey; pleurae with marked ashy sheen. Legs fawn, usually with darker knees and some darker suffusion towards ends of segments. Abdomen with tergites brown, sometimes dark, but not velvety.

*Male*: Third antennal segment not much longer than fourth, calcipala barely half width of metatarsus, otherwise as *A. furiosum*. Style of hypopygium with two, sometimes three, spines; posterior part of phallosome with a patch of denticles ventrally on each side.

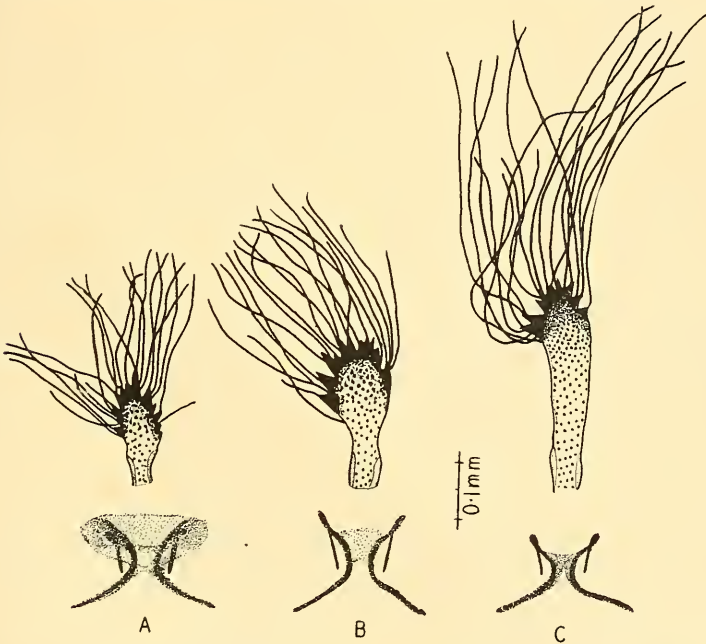
*Cocoon*: Flat, rounded, with a narrow, raised, central part to contain the body of the pupa, and with a small, oval opening into which the head and anterior part of the pupal thorax fit neatly; margin of opening with thickened, rolled edge.

*Pupa*: Remarkable for the flattened head and anterior part of the thorax, adapted to fit exactly to the aperture in the cocoon, with only the respiratory apparatus projecting beyond its general surface. Horn very short, broad, orange basally, black distally, where it is armed with stout black spines (Fig. 18A). The filaments are short, fine, 15-20 in number, and arise from the distal end of the horn. The thorax bears on each side a raised, blunt tubercle just behind the base of the respiratory horn, and a stout, dark, backwardly directed spine over the post-alar area of the underlying adult. These structures are present in all the races of *A. torrentium*, but we have not seen them in any other species.

*Larva*: Antennae with distal segment only about half the length of the basal; margin of submentum evenly curved; anal sclerite stout, with a somewhat irregular, brown, chitinous expansion of its anterior limbs (Fig. 18A). The gill spot shows the black spines even at an early stage of development, and, when fully formed, has the perfect form of the pupal horn, with the filaments curved in an anterior tuft.

*Distribution*.—Tasmania: St. Patrick's R., Nov. (*type locality*); Burnie (Emu R.), Oct., Feb.; Launceston (Cataract Gorge), Oct.-Jan.; Cradle Valley, Jan.; Mt. Farrel, Feb.; all coll. Tonnoir.

*Biology*: Adults have been taken by sweeping plants. The early stages were found in larger streams with a very swift flow, to which the form of the cocoon and pupae seem specially adapted. Tonnoir notes that the prepupal larvae seek indentations in the stones, "which the cocoon closes like a flat lid". We have not seen a similar adaptation to unusually fast water elsewhere in the family, even in *A. pestilens*.



Text-fig. 18.—Pupal horns and anal sclerites of races of *A. torrentium*.  
A: *A. torrentium torrentium*; B: *A. torrentium* var.; C: *A. torrentium hilli*.

*AUSTROSIMULIUM TORRENTIUM HILLI*, n. subsp.

Mainland specimens fall in two groups, both differing from Tasmanian specimens in larval characters, and one also in pupal characters. The differences appear to be constant, and we propose to associate the name of our friend, Mr. G. F. Hill, with the more distinctive of the two.

*Adult*: Female rather lighter in general colouration, otherwise both sexes similar to typical subspecies.\*

*Cocoon*: Smaller and more oval than typical subspecies; opening egg-shaped, margin smooth and only slightly thickened. Tonnoir notes that cocoon is covered in life with a gelatinous material, which gives it a milky appearance.

\* Propleural hairs were absent in *torrentium* (two specimens), present in *hilli* (four specimens), and present in nine, absent in eight of the females associated by Tonnoir with the variant described below. An analysis of the propleural hairs in further accurately associated series of the three forms might be interesting.

*Pupa*: The flattened head and thorax, general habitus, and armature as in typical subspecies. Respiratory horn about twice as long and not so broad (Fig. 18C), coloration as in typical subspecies, but apical spines fewer and weaker. Filaments slender, about 30 in number.

*Larva*: The anal armature (Fig. 18C) is relatively delicate, and there is no trace of the chitinous expansion of the anterior limbs, which is characteristic of the typical subspecies. Gill-spot with stem long, as in pupa, and spines relatively inconspicuous. The margin of the submental plate is scalloped (like *A. cornutum*, Fig. 16), but the antennae, circelet, and ventral papillae are as in typical subspecies.

*Types*: We feel it necessary to follow the unusual course of designating a full-grown "gill-spot" larva from Cotter R., A.C.T., 10 Oct., '29, Tonnoir, as holotype. Morphotype pupa, adult female, and adult male have been selected from the same series. All types are in the collection of the Division of Economic Entomology, C.S.I.R., Canberra.

*Distribution*.—A.C.T.: Cotter R., Oct.-Nov. (*type locality*). New South Wales: Yarrangobilly R. (near Caves), Feb.; Mt. Kosciusko, Thredbo R., Dec., Snowy R., Feb. All coll. Tonnoir.

*Variation*: The second form mentioned above links *hilli* with *torrentium*, though in a distinct step without intermediate grading. The anal sclerite of the larva (Fig. 18B) and submental plate are similar to those of *hilli*, but the pupal respiratory horn (and consequently the gill-spot of the larva) is short, broad, with strong spines, like a more than usually robust *torrentium*. Cocoon more like typical subspecies, often asymmetrical. In short, adults and young larvae cannot be separated from *hilli*, pupae are identical with *torrentium*, and only the full-grown "gill-spot" larva is definitely recognizable as a separate entity. Tonnoir had carefully linked bred series from Cotter R., Oct. (in company with the type series of *hilli*) and the Cotter-Murrumbidgee Junction, Oct. There are specimens also from Cotter R., Sept.-Nov.; Five Fords, Dec.; Mt. Kosciusko (Digger's Ck., Thredbo R.), Dec.; all coll. Tonnoir.

The status of the three forms is difficult to assess. We have been conservative, but possibly they are sibling species, which have diverged sufficiently not to breed together when they meet (as the two mainland forms do in the Cotter R.).

Tonnoir (MS.) noted an abnormality in about 5 per cent. of the males of the "short-horned" variant, the scutum being shining grey, the hind metatarsi more incrassate than normal, and the size and distribution of the enlarged facets of the eye differing from normal. He queried these abnormal males as possibly gynandromorphs. A pinned specimen in the collection has female scutal and leg coloration, but is a male in other respects; the spirit material, unfortunately, had dried.

*Biology*: Habits of adults unknown. Early stages in swift, clear water, apparently occupying the same type of situation as the typical form.

#### NEW ZEALAND SPECIES.

We have nothing to add to Tonnoir's descriptions so give only brief notes on the New Zealand species.\*

##### AUSTROSIMULIUM VEXANS (Mik).

Tonnoir, 1925, p. 250. Known only from female; has toothed claws. Auckland Is. (*type locality*).

##### AUSTROSIMULIUM UNGULATUM Tonnoir.

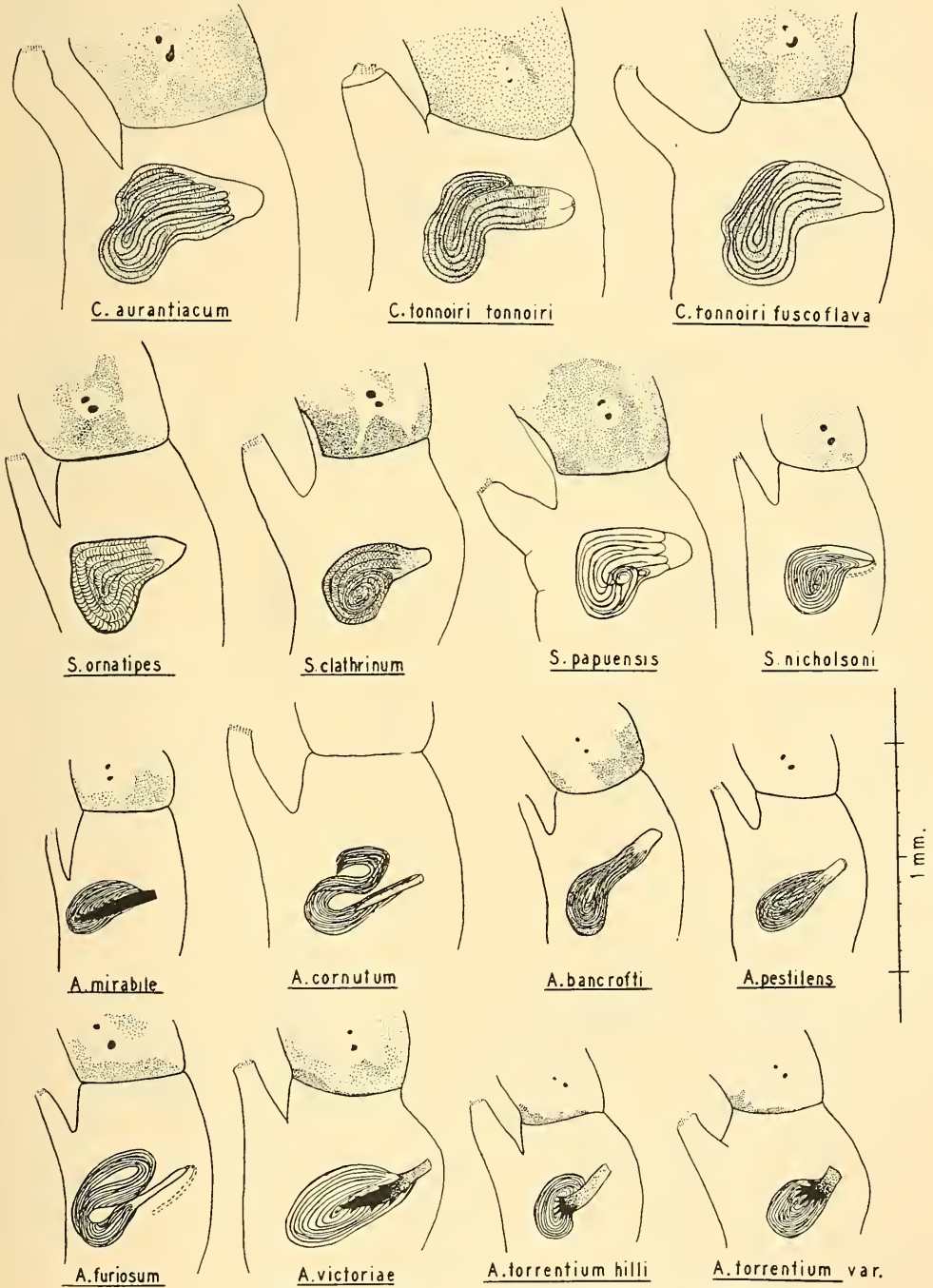
Tonnoir, 1925, p. 250. Known only from female; has toothed claws; a fierce biter. South Island (Reefton, *type locality*).

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\* To complete the list, it should be mentioned that Edwards (1931, pp. 143 and 144) records *Austrosimulium anthracinum* (Bigot) and *A. moorei* (Silva) from Patagonia and Chile. Both are known only from adult females.

AUSTROSIMULIUM AUSTRALENSE (Schiner).

Tonnoir, 1925, p. 251. Genotype of *Austrosimulium*. Larva, pupa, cocoon, female and male known. A small, unadorned species with simple female claws; appears to be a



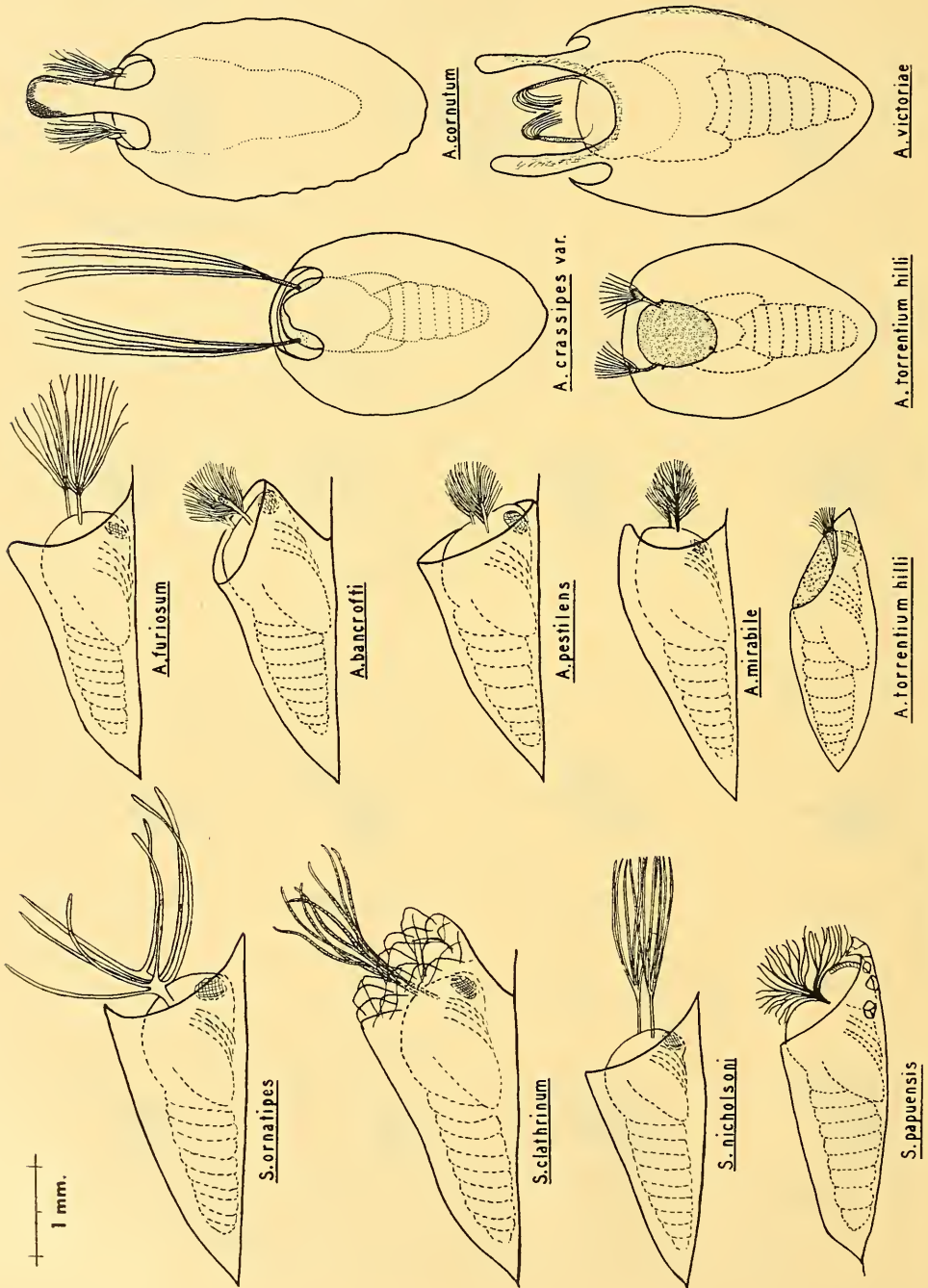
Text-fig. 19.—Lateral view of full-grown larvae, showing gill-spots.  
 (For *A. crassipes* see Fig. 13D; for *papuensis* read *papuense*.)



fairly central member of the genus on the characters of all stages. Bites man. North Island (Auckland *type locality*), South Island.

AUSTROSIMULIUM TILLYARDI Tonnoir.

Tonnoir, 1925, p. 253. Larva, pupa, cocoon, female and male known. A small, undistinguished species with simple claws, but with an unusual pupal respiratory organ which may provide a link with other genera. Not known to attack man. North Island, South Island (Nelson *type locality*).



Text-fig. 20.—Cocoons and pupae. For *Caenophia* type, see Fig. 11.  
(For *papuensis* read *papuense*.)

## AUSTROSIMULIUM LATICORNE Tonnoir.

Tonnoir, 1925, p. 253. Larva, pupa, cocoon, female and male known. Distinguished from *A. tillyardi* only by pupal respiratory organ. Not known to attack man. South Island (Waiho *type locality*).

## AUSTROSIMULIUM MULTICORNE Tonnoir.

Tonnoir, 1925, p. 254. Larva, pupa, cocoon, female and male known. Distinguished from above only by pupal respiratory organ. Not known to attack man. North Island, South Island (Mt. Arthur *type locality*).

## AUSTROSIMULIUM LONGICORNE Tonnoir.

Tonnoir, 1925, p. 254. Larva, pupa, cocoon, female and male known. Only distinguished from above by the remarkable pupal respiratory organ which, like that of *A. tillyardi*, may link with other genera. Not known to attack man. North Island, South Island (Kaikoura *type locality*).

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